SCIENCE TEACHER'S WORLD

Teacher's edition of SCIENCE WORLD January 13, 1960

For Teachers of Science
PLEASE ROUTE TO:

Using *Science World* in Your Teaching

Nature's Volcano Laboratory (pp. 5-7)

General Science Topic: Our changing earth

Earth Science Topics: Volcanism, volcanology, petrology

Physics Topics: Specific gravity, Archimedes principle

About This Article

Hawaii is now one of our United States of America, and it is good to get acquainted with names such as Halemaumau, Kilauea caldera, Kilauea Iki. These happen to be places that were involved in the volcanic eruptions last November – eruptions that attracted thousands of observers. But on the scene from the very first were members of the staff of the Hawaiian Volcano Observatory, an institution for the scientific study of volcanism that was established back in 1912 and is administered by the U.S. Geological Survey.

Mr. Gieseking's article deals with volcanism as a natural phenomenon which, incidentally, is responsible for bringing the Hawaiian Islands into being. It deals with some of the instruments used by volcanologists, some of the kinds of observations these scientists make, and the suitability of Hawaii as a location for a volcano observatory. Here is a timely, vivid, and truly dramatic piece for students in General Science and Earth Science classes.

Topics for Class Reports

1. Explain why volcanos have been called "exterior decorators."
2. Tell the story of the origin and geological history of the Hawaiian Islands.
3. Tell about how the Army Air Corps once diverted lava issuing from an erupting volcano.
4. Describe four kinds of instruments used by volcanologists.
5. What causes volcanos to erupt?
6. What evidence of volcanic action is found in Oregon, Washington, Idaho, and Southern California?

Bottling the Sun (pp. 8-12)

Chemistry Topic: Atomic fusion

Astronomy Topic: Stellar evolution

Physics Topics: Boyle's law, Charles' law, Stefan-Boltzmann law, thermonuclear reactions, measurement of temperature in stellar bodies

About This Article

Scientists and engineers in several countries are presently preoccupied with trying to effect a controlled thermonuclear reaction. This article presents some history and information behind this quest. Into the historical picture the writer brings together the astronomer Sir Arthur Eddington, the theoretical physicist Hans Bethe, and the mathematical physicist Albert Einstein. Into the informational picture he brings the plasma jet, the pinch phenomenon, and the "magnetic bottle."

The article goes further: it carries us into the very midst of this exciting enterprise by describing work with the machine called ZETA, and it peers beyond, into the future, when controlled thermonuclear reactions will have been achieved.

Topics for Discussion

1. How was the thinking of Hans Bethe influenced by the findings of Sir Arthur Eddington?
2. Describe what takes place within atoms as matter is being converted into plasma under the influence of ultra-high temperature.
3. Why did Hans Bethe call the thermonuclear reaction in the sun the "carbon cycle"?
4. What principle explains both the Earth's and the sun's interior heat?
5. What terrestrial phenomena may be regarded as plasmas?
6. By what methods are plasmas being made for experimental purposes?
7. Describe each of these: "plasma jet," "pinch phenomenon," "magnetic bottle."
8. By what devices are scientists at the present time trying to achieve controlled thermonuclear fusion?

Immunity – Shield Against Disease (pp. 13-15)

General Science Topic: Fighting infectious diseases

Biology Topics: Immunity to disease, allergies

About This Article

A brief and "traditional" treatment of body defenses against disease organisms is followed by a consideration of some hypotheses concerning the immunization process itself. The writer then proceeds to give an account of some experimentation in the field of immunology and of what the findings of this experimentation suggest in the way of further hypotheses about the mechanism of immunization.

In the remainder of the article, the author extends the concept of antigen-antibody reaction to such phenomena as allergy and body reaction to tissue

grafts. Further experimentation described in the article suggests that the source of antigenic material may well be the cell nucleus—more specifically, its nucleoproteins—perhaps DNA itself.

Topics for Class Reports

1. Describe an experiment in which the rate of antibody formation was actually measured.
2. Describe an experiment which suggests that antigens may be located in the nuclei of cells.
3. Explain the relationship between allergies and the immunity process.

Note: In connection with this article, biology teachers may wish to suggest to interested students an inexpensive reference: Nicol, Hugh: MICROBES AND US (Pelican)

Tomorrow's Scientists Separation Process for Algae (pp. 21-23)

Biology Topics: Microorganisms, nutrition, photosynthesis
Chemistry Topics: Ion exchange resins, surface phenomena
Physics Topics: Instrumentation (Use of photometer or colorimeter for measuring density of a microbial population)

About Larry Dahlkvist's Project

The objective of Larry's technical study was to find a practical method for separating chlorella cells from the culture medium in which they are grown.

One of the methods Larry considered is based on the fact that, with maturation, the surface of the chlorella cell becomes negatively charged, and hence the cells are subject to attraction to a positively charged electrode. To obviate the use of electric current, Larry made use of a positively charged polymer produced by the Dow Chemical Company. This polymer attracts to itself the mature chlorella cells; the cells are then removed by filtration of the flocculant.

Larry proceeded to investigate a number of factors that might speed the process. His investigations will interest biology teachers who may have students working with algae. Chemistry teachers who are curious about "Separan Flocculants" may wish to write to the Dow Chemical Co. for literature.

Today's Scientist Nobel Geneticist (p. 20)

Biology Topics: Genetic mutations, nutrition (vitamins), mycology.

This life story of Dr. George Beadle, the Nobel-Prize winning investigator, contains also a description of his prize-winning experiments. In themselves, the experiments of Beadle and Tatum are as elegant in their simplicity as they are significant in their theoretical importance. These experiments fit beautifully into the Mendel-Morgan-Muller story in the high school genetics unit. For this reason alone, this article would make its contribution in the biology classroom.

But it accomplishes more; it serves to give students an appreciation of each special branch of science (like each school of art) as a grand tradition in which Masters hand down the torch to young disciples who carry on to attain new heights of achievement. The fact that Dr. Beadle is a contemporary makes his life story all the more exciting.

Attention might also be directed to Dr. Beadle's eloquent and moving message to youth, addressed to the readers of *Science World*, which will be found on the contents page under "Science in Quotes."

Meeting the Test (p. 25)

For science teachers, the implications of Dr. Theodore Benjamin's *Meeting The Test* are important and far-reaching. Here are four implications:

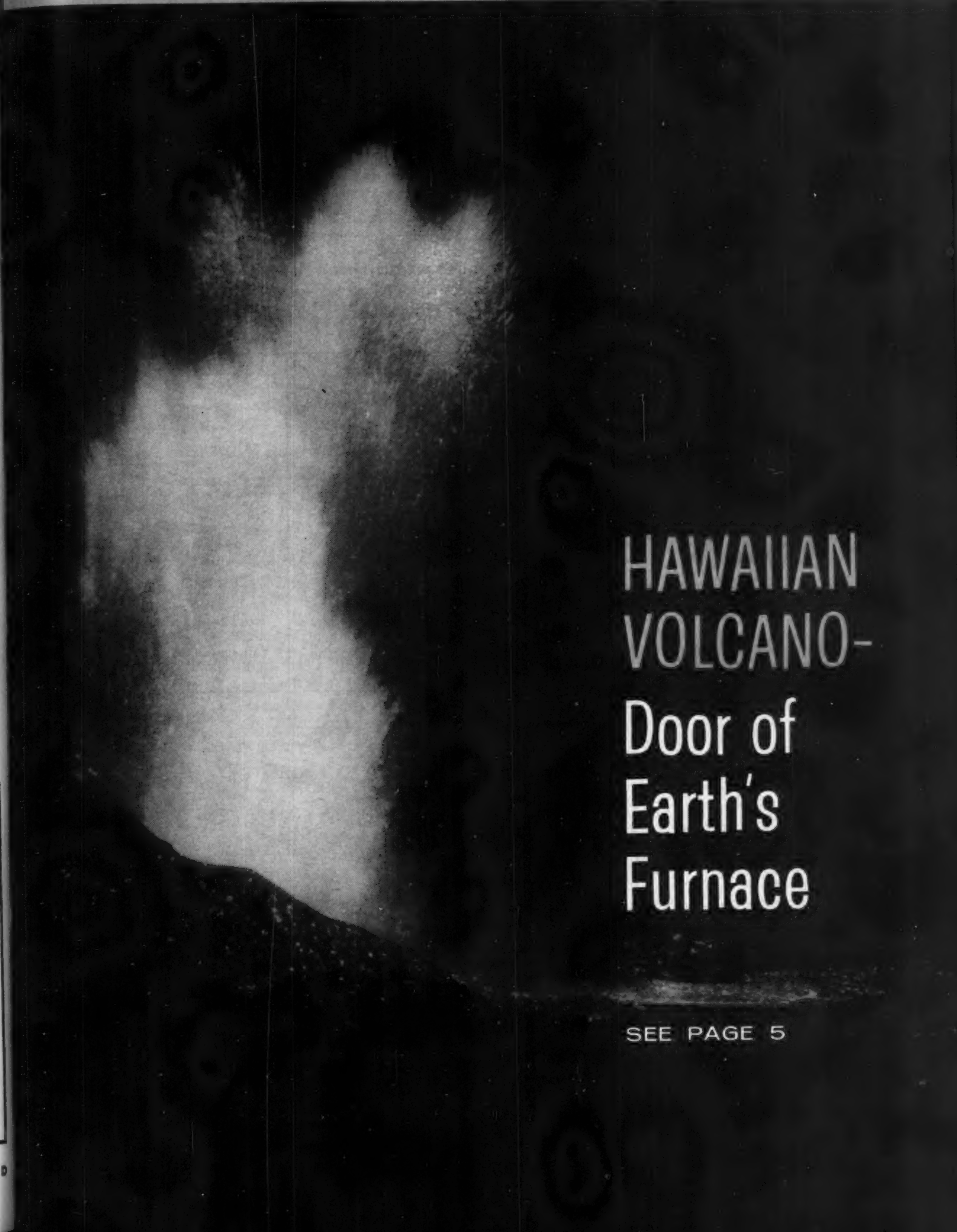
1. Somehow, we must contrive to give students in all science classes and on all levels experience in gathering data and organizing such data in tabular or graphic form. (In more advanced science classes, the logarithmic graph and its rationale should be introduced; attention might be directed to the logarithmic temperature scale on page 9.) This experience can go a long way in enabling students to appreciate and interpret data gathered and organized by others.
2. Having gathered and formulated their own data, students should be afforded the experience of "drawing conclusions." In doing so, students could be led to grow in sensitivity to the adequacy, sufficiency, and pertinence of the data with respect to any proposed "conclusions."
3. In planning courses of study and in lesson-planning, it is well to be aware of "places" where tabulations and graphs might be brought into day-to-day science teaching.
4. Class tests, end-of-unit, mid-year, and end-of-year examination papers should include some questions such as those offered by Dr. Benjamin to measure the degree to which students have grown in their ability to interpret data.

Science Teachers World would be happy to hear of products of teacher creativity along these lines.

Future issues of *Science World* will include interpretation of diagrams and flow charts in biology, reaction phenomena in chemistry, and interpretation of concepts in physics and earth science. We suggest students save these pages.

SCIENCE WORLD

NUARY 13, 1960 • VOLUME 6 • NUMBER 8 • A SCHOLASTIC MAGAZIN



HAWAIIAN VOLCANO— Door of Earth's Furnace

SEE PAGE 5

SCIENCE WORLD, published fortnightly, 16 times during the school year September through May. Second-class mail privileges authorized at Dayton, Ohio. Contents copyright, 1960, by Scholastic Magazines, Inc. SUBSCRIPTION PRICES: $1.50 a school year each, or $1.00 a semester each. Single subscription, Teacher's Edition, $2.00 a school year. Single copy, 15 cents. Office of Publication, McCall St., Dayton 1, Ohio. General and Editorial Offices, SCIENCE WORLD, 33 West 42nd St., New York 36, N. Y.

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The Staff

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Cover photograph by Jerry Chong

Science in Quotes

In the research that is the life of science there are unlimited opportunities to explore the unknown, to discover facts of which man has never before been aware, and to relate new knowledge to old in ways that reveal afresh the oneness and the beauty and the grandeur of science. In this there is satisfaction of a depth and a kind that can never be appreciated except by one who experiences it.

In short, science is fun.

The science of tomorrow will be built by the youth of today. I know they will respond to the challenge and the opportunity.

—DR. GEORGE W. BEADLE, *Nobel Laureate*
Message to *Science World* readers (*see page 20*)

U.S. MAIL

Letters

Melting Snow

Dear Editor:

With the first snow this year I noticed something very interesting. The night before, snow had fallen on the tops of two cars. One car top was white and the other was black. When the sun came out I noticed that the snow on the black top melted faster than the snow on the white top. Could you tell me why?

Gerald Beneteau
219 Lauzon Rd.
Riverside, Ontario, Canada

Answer: The sun radiates energy of various wave lengths. Some are wave lengths of light, some wave lengths of heat. When these waves of energy strike a surface they may be absorbed or reflected. When they are reflected the surface appears light and it remains cool. When they are absorbed the surface appears dark and it warms up. The black-topped car had an absorbing surface. Its surface got warm and melted the snow rapidly. The white-topped car had a reflecting surface. It remained cold and the snow on it did not melt so rapidly.

Salt from Sea Water

Dear Editor:

Can you tell me how salt can be removed from sea water?

Ernest S. Knighton
100 Arbor Street
Greenville, S. C.

Answer: One way of removing salt from sea water is by evaporation. If sea water is heated or boiled, the steam that rises is pure water vapor. If this vapor is trapped and condensed, it will be free of salt. The salt will be left behind in the boiler. This process is called distillation. Distillation has been used for centuries to extract salt from sea water. It is also a means for making very pure water for laboratory purposes. Another method is to filter the sea water through certain chemicals or resins. These resins attract the salt molecules, removing them from the water. This is called the ion-exchange process. It is used aboard lifeboats and life rafts as an emergency method of obtaining drinking water.

Orbiting Satellite

Dear Editor:

I read in the Nov. 19, 1959, issue of *Science World* that every time an orbiting satellite passes near the Earth, the drag of the atmosphere slows it down and narrows its orbit. Why does this happen?

Linda Ford
Rt. 3, Box 329
Bristow, Okla.

Answer: The orbit of a satellite depends on its speed. The greater the speed, the wider and longer the orbit. Every time the satellite passes through the Earth's atmosphere, the friction of the air slows it down. Its slower speed means it must travel in a smaller orbit.

Forces in the Nucleus

Dear Editor:

If positive charges repel positive charges, why don't the protons in the nucleus of an atom repel each other, so that the nucleus flies apart?

Don Souders
201 Floral Avenue
Leechburg, Penna.

Answer: This is a problem which has puzzled atomic scientists for many years. They know that there is a gravitational force which attracts the protons to each other. However, they have calculated that this gravitational force is not sufficient to overcome the electric forces of repulsion between the protons. Therefore, they theorize that other forces must be at work. The best theory to date is that the distances between the particles in the nucleus are so short that the particles become "hooked together" in some way by other forces and are prevented from flying apart. Atomic scientists are doing much research to find out more about the forces inside the nucleus.

Interplanetary Weight Chart

IF YOUR EARTH WEIGHT IS—	Weight on other planets: MOON	SUN	VENUS	MARS	JUPITER
70 lb.	11	1952	60	27	185
80 lb.	13	2231	68	30	211
90 lb.	14	2510	77	34	238
100 lb.	16	2789	85	38	264
110 lb.	18	3068	94	42	290
120 lb.	19	3347	102	46	317
130 lb.	21	3626	111	49	343
140 lb.	22	3905	119	53	370
150 lb.	23	4184	128	57	396
160 lb.	25	4462	136	61	422
170 lb.	27	4741	145	65	449
180 lb.	28	5020	153	68	475
190 lb.	30	5299	162	72	502
200 lb.	32	5578	170	76	528

Craters on the Moon

Dear Editor:

Why does the moon have more craters than the Earth?

Mark Phipps
12248 N. Linden Rd.
Clio, Michigan

Answer: One theory answers the problem in this way: When the moon was first formed, millions of years ago, it was molten rock. The lunar craters were created at that time by large meteors crashing into the moon's surface. The sides of the craters were made of liquid rock thrown up by the meteors' crash. This liquid rock later cooled into solid rock mountains. On the Earth most meteors were burned up in the Earth's atmosphere before they could reach the ground. Since the moon has no atmosphere, there was nothing to stop the meteors from crashing and forming craters.

Your Weight on Jupiter

Dear Editor:

Why would you weigh more on the planet Jupiter?

Michael Hromoko
33 Read St.
Newark, N. J.

Answer: Your weight on any planet depends on the gravitational attraction of the planet. The gravitational force of a planet depends on its mass, that is, the amount of matter in the planet. Since Jupiter is the largest planet, it would exert a greater gravitational attraction than any other planet. You would weigh so much on Jupiter that you would be unable to walk—each of your feet might weigh a hundred pounds (*see chart at left*).

By HAL GIESEKING

Nature's Volcano Laboratory

At the Volcano Observatory on Hawaii scientists study at first hand the fiery processes that shape the Earth

Photo by Jerry Chong from Camera Hawaii

"THE door of earth's furnace has just opened," an observer wrote. "Twelve fountains of lava are emerging from a rift over halfway up the crater wall. The sound is like a dozen jet bombers roaring overhead. The fountaining lava blends into a red-orange river that slashes through trees and splashes its way to the Kilauea Iki floor. On the floor a dark lake is growing. The top of the lake is black, cooled lava. The lake wears many red-gold necklaces . . . cracks revealing the glowing lava below."

Scientists at the Volcano Observatory on the "Big Island" of Hawaii knew the recent eruption was coming. On more than a dozen seismographs they had carefully noted the increasing number of quakes in the Kilauea caldera—the large crater formed by the collapse of the central part of the volcano. They had watched the swelling of the Kilauea dome as recorded on tiltmeters. In one week in May last year, over 2,500 local earthquakes were recorded.

On November 14, Dr. Jerry P. Eaton, a volcanologist on the staff of the Hawaiian Volcano Observatory, reported: "There have been 2,200 small earthquakes on Halemaumau in the past 24 hours." Halemaumau was a "fire pit" on the floor of the Kilauea caldera. At 8:08 p.m. that evening an orange glow appeared in the sky over Kilauea Iki. The 1959 eruption had started.

What Causes an Eruption

On November 16 volcanic action became concentrated in one vent. The fountain from that vent climbed to 100 feet, 200 . . . a towering 1,150 feet. This eruption died on November 21, but there has been a continuing series of eruptions since that date. At the time of this writing there has been a total of 14 separate eruptions. During the third eruption, the lava fountain created a new world's record by reaching a height of 1,700 feet (450 feet higher than the 1,250-foot Empire State Building).

Hawaii's record of continual eruptions and volcanic action in recent history has made it an ideal laboratory for studying one of the fundamental building processes of our earth. The Hawaiian Volcano Observatory was officially organized in 1912 by a group of Honolulu businessmen and the Whitney Foundation of the Massachusetts Institute of Technology. A small staff of geologists was housed right on the rim of Kilauea caldera. The United States Geological Survey runs the observatory.

What causes a volcanic eruption? One popular explanation in ancient times was that a "strange wind" set seams of coal and sulphur on fire. Even as late as the 1800's, some scientists ascribed volcanos to the combustion of coal seams deep within the earth. Scientists at the Hawaiian Volcano Observatory and other volcanologists have discovered other explanations.

The earth's crust is, of course, not

Photo by Jerry Chong from Camera Hawaii

Hill did not exist in early part of November 1959. It was created by material ejected from volcano during 1959 eruption. A scarred tree is partially buried.

uniform. It is composed of many types of material. In many areas "faults" exist. These are fractures in the earth's crust, where one side has moved in relation to the other side of the fracture. The magma, the molten rock and gases flowing beneath the earth's crust, is constantly seeking a new approach to the surface. When it finds a "fault" or "rift" the magma finds its way upward. If it is stopped before reaching the surface, the magma solidifies to become what geologists call an "intrusion." Erosion is constantly exposing "intrusions" of igneous rock (rock formed by the solidification of molten rock). If, however, the magma reaches the surface, it becomes a form of volcanic action—either a steady flow of lava or an explosive eruption throwing rocks many miles.

Magma has been described chemically as a "complex mutual solution of silicates and oxides." It also contains gas in solution or enclosed in bubbles, and crystals of various minerals. The most common Hawaiian lava is olivine basalt. When magma reaches the surface it is called by the familiar name "lava."

"There are two principal reasons why magma rises to the surface," explains Dr. Gordon Macdonald, former head of the Hawaiian Volcano Observatory and senior professor of geology and geophysics at the University of Hawaii. "First, magma rises because it's lighter than the solids around it. You can demonstrate this process by depressing a board with a center hole in a bucket of water. The liquid 'erupts' through the center hole because it's now 'lighter' than the depressed board.

"The second reason is demonstrated when you open a bottle of soda. The carbon dioxide in the soda has been held in solution by pressure. When the pressure is removed by opening the bottle, some of the gas escapes with a 'pop.' Magma has a high content of gas. When the magma approaches the earth's surface, there is much less pressure from the crust. This reduced pressure allows gas to escape from solution and to form bubbles in the magma. We call this 'vesiculation' or frothing. This vesiculation helps to expand the total volume of magma and to force it out on the surface of the earth as a fountain of lava."

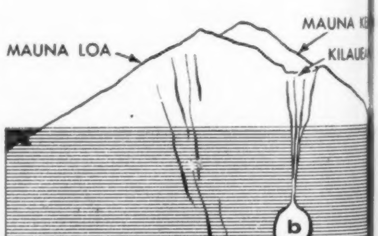
Tools of Volcanologist

A "rift" can be described as a fracture in the earth's crust. (Unlike a "fault," however, there is not necessarily a movement of one side in relation to the other.) There are two rift zones which have allowed magma to reach the surface, forming the volcano Kilauea. Kilauea is one of the three major volcanos on the island of Hawaii. The other two are the massive 13,680-foot Mauna Loa, the world's largest active volcano, and Mauna Kea, which has not erupted in the history of the Hawaiian people. Kilauea Iki ("Iki" means "little") is a small crater located by the side of its 2,600-acre "big brother," Kilauea.

"We believe that 25 to 30 miles beneath Kilauea is a magma basin," says Dr. Macdonald. "We base this belief on the fact that earthquakes recorded on seismographs seem to originate from this depth. Approximately three to four miles down is a reservoir of magma. The magma flows upward, fills the reservoir, and may then force its way up one of the rift zones to the surface as an eruption. It's the swelling of this reservoir that tilts the Kilauea dome. We record this tilting with tiltmeters. These measurements become one of our indications of a possible future eruption."

The tiltmeters at the Hawaiian Volcano Observatory are composed of two water-level pots connected by 150 feet of pipe embedded in the earth. When the swelling of the earth tilts the pipe, the degree of tilt is measured by the water level on a micrometer-like scale.

Seismographs are also vital tools of the volcanologist. A seismograph makes use of the principle of inertia, the tendency of a mass to remain at rest. When a weight is suspended by a string it will tend to remain at rest even though the earth beneath it may make a sudden movement. The difference in movement between the



Cross-section of "Big Island" of Hawaii. According to present theory, magma from basin 25-30 miles below surface (a) flows to magma reservoir (b). Swelling of reservoir tilts ground above. Magma may continue up through "rift" to surface.

unmoving weight and the moving earth can be recorded on a revolving drum. There were many problems which geologists and physicists had to overcome in developing seismographs.

The friction produced when the weight records the earth's movements interfered with accuracy. Also, the weight had to be "damped" once it too was brought into motion. Once started in motion, the weight would continue to swing after the earth movement had stopped, producing an erroneous record. "Damping" is accomplished by creating a drag on the moving weight, which brings it back to a position of rest.

Many volcanologists now use electromagnetic seismographs. Friction is eliminated as a problem. A galvanometer mirror records earth movements with a light on photographic paper. The seismographs at the Hawaiian Volcano Observatory are electromagnetic.

In addition to recording "harmonic tremors" which indicate the movement of magma beneath the earth and recording the tilting of the earth on tiltmeters, volcanologists at the observatory were keenly interested in obtaining samples of the lava as it poured from the central vent during the current eruption. They donned fire- and heat-resistant suits in order to approach the "pure" lava—lava not contaminated by contact with exterior rocks.

Two Types of Lava

To get a visual idea of the two basic types of Hawaiian lava, cut a slice from a chocolate cake. The smooth icing at the top represents pahoehoe lava. This lava flows directly from the volcano vent and solidifies into igneous rock with a smooth or ropy surface. If pahoehoe is "stirred" by flowing against a boulder or plummeting over an embankment, it may become the second type of lava—aa. Aa is visually represented by the texture of the cake beneath the icing. Aa has a rough, clinkery texture. The conversion of pahoehoe to aa seems to be caused by differences in the states of the gas in both when they solidify.

Volcanos have been described as "exterior decorators" because of the changes they make on the landscape. They may swell the land into new shapes by the action of magma beneath the crust. Material ejected from an erupting volcano, such as pumice and volcanic glass, may be found many miles from the vent. Volcanos may build new mountains and create new islands. They also bring minerals to the earth's crust. The breakdown of molten rock has yielded sands, iron, and salts.

Volcanic action has taken place on every continent. There are about 500 volcanos now active in the world. One example of the importance of volcanic action is found in the states of Oregon, Washington, Idaho, and northern California. Over 200,000 square miles of these states are covered by lava flows. Mount Rainier, Mount Hood, Mount Baker, Mount Shasta, and the other peaks of the Cascades were formed by volcanic action.

Islands—Tops of Volcanos

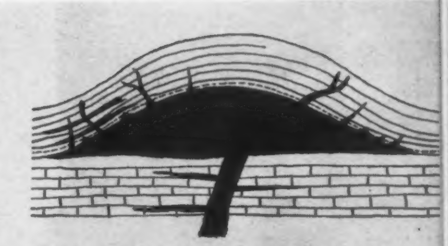
The Hawaiian chain of islands would not exist today if it were not for volcanic action. In the geologic past, a vast fissure opened on the floor of the Pacific Ocean. The fissure ran in a northwest-southeast direction. Through this fissure, tons of molten rock poured in ocean-bottom eruptions. Gradually the thousands of eruptions began to build mountains in the sea. The mountain tops finally rose above sea level, becoming the Hawaiian Island chain.

Then erosion began its work, carving out valleys and other features in the fresh land. The volcanic action continued, blotting out at times the changes wrought by erosion and, in turn, having its lavas attacked by erosion.

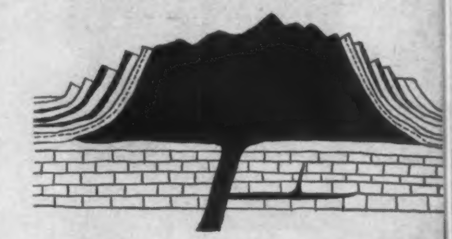
At times the eruptions have been small lava fountains within a crater. At other times they have been gigantic spectacles that would dwarf Hollywood's imagination. When Mauna Loa erupted in 1950, a line of vents 16 miles long threw lava up to a height of 1,000 feet.

When quakes rocked the "Big Island" of Hawaii in 1924, the pit walls of Halemaumau collapsed. Ground water poured into the pit, and a gigantic steam explosion followed. Five separate explosions sent rocks 2,500 feet high. One was a block weighing 14 tons!

When Mauna Loa erupted in November of 1935, it pointed a lava



Magma may not reach surface. Here magma has created hill by forcing top layers of rock upward. Magma may now solidify and become what is called an "intrusion."

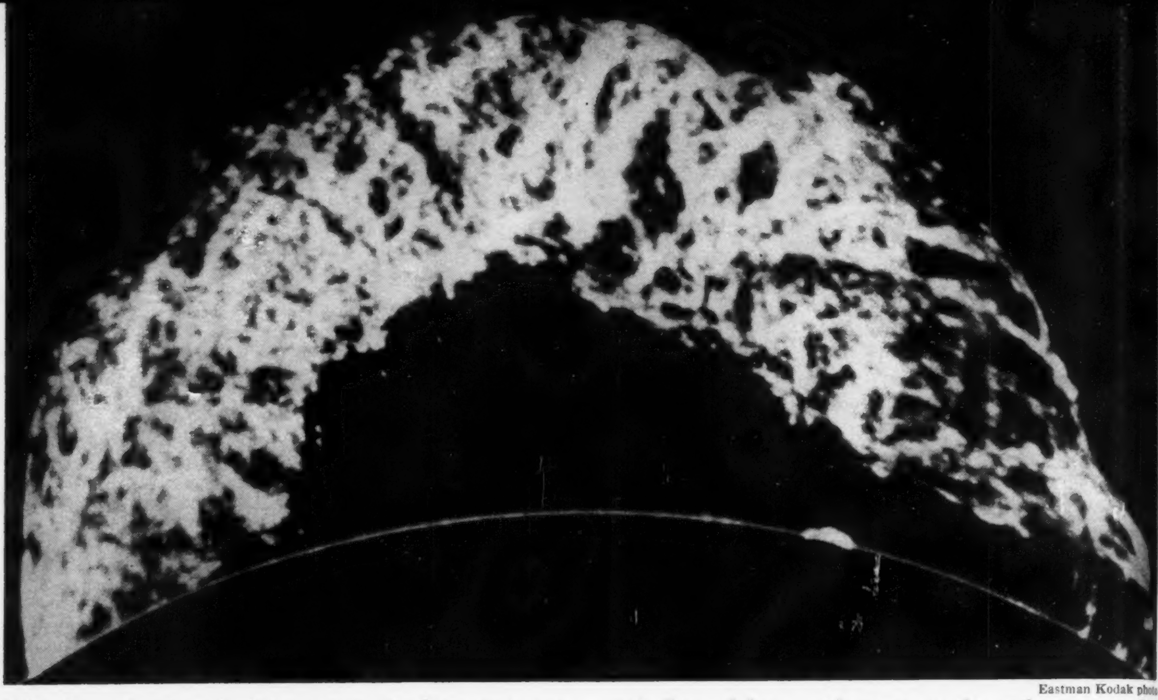


"Intrusion" may be exposed by erosion. When you find igneous rock on earth's surface, it may be from exposed "intrusion" instead of from past volcano eruption.

finger at Hilo, the largest city on Hawaii. Under the direction of Dr. Thomas A. Jaggar (the M. I. T. scientist who helped to found the Hawaiian Volcano Observatory), the Army Air Corps bombed the main source tunnel of the lava. As Dr. Jaggar had theorized, the rush of cool air through the new holes in the tunnel solidified the lava into an effective plug. This diverted the lava into other directions, stopping the flow of lava toward Hilo. The bombing was successfully repeated on a 1942 lava flow.

Hawaii's volcanos have been described as "gentle" volcanos. They can be observed at close range because the eruptions seldom have the violence associated with volcanos in other parts of the world. Their gentleness seems to be caused by the fact that enclosed gas can escape easily without any build-up of explosive pressure. Another reason advanced by volcanologists is the possibility that Hawaiian magma has a lower gas content than magma found elsewhere.

Hawaii has become nature's volcano laboratory for scientists, where they can study at firsthand some of the fiery processes that continue to form and shape our earth.



Eastman Kodak photo

Solar flare of extremely hot gases erupts from sun's surface. Stream of hot ionized gases curves along sun's magnetic lines of force, and returns to the surface at another point. To make this photo, disk of the sun was blotted out.

By SIMON DRESNER

BOTTLING THE SUN

Scientists create the ultra-high temperatures of the stars inside the laboratory

WHEN man first realized that the sun was the source of all the energy on Earth, he began to worry: How long would it be before the sun burns itself out? He thought the sun was burning like a candle, whose flame would one day be extinguished. The Earth and the planets would receive no heat or light, and would spin through space in cold and darkness. Man and all other forms of life would perish on a frozen world.

Today scientists think that before the sun grows cold, it will grow hotter. In about 500 million years the sun will be three times as brilliant as it is now. It will be hot enough to raise the average temperature of the Earth to the boiling point of water. All the water will evaporate into the atmosphere and the Earth will become a desert. Man will be unable to survive in the scorching heat. All life on Earth will be burned into extinction.

After the Earth is silent, the sun will continue to grow. It will become 200 or 300 times its present size, engulfing the planets Mercury and Venus. The Earth will be a mass of boiling molten rock. Then the sun will slowly shrink once more to about its present size. Instead of being yellow, however, it will be blue, and be twice as bright as the sun is today. Strange new forms of life may appear on Earth, under an unfamiliar glaring blue sky.

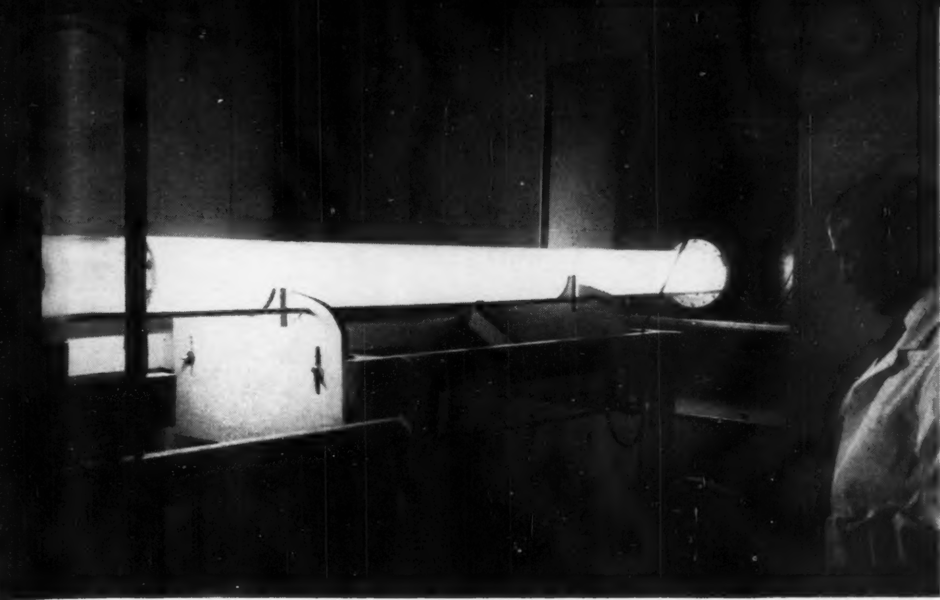
Why predict such a fantastic evolution for the sun? The first clue to the gigantic processes going on inside the sun was uncovered in 1930 by the great British astrophysicist, Sir Arthur E. Eddington.

Plasma in the Sun

Sir Arthur showed that the sun is a mass of extremely hot, dense gas—so hot that the interior temperature is 15 to 30 million degrees Centigrade. This temperature is about the same as that inside a hydrogen bomb at the moment of explosion. In fact, Dr. Hans A. Bethe, an atomic physicist of Cornell University, has calculated that the interior of the sun is equal to 10 billion billion (10^{18}) exploding hydrogen bombs. He has theorized that this is the way in which the sun creates the gigantic amounts of energy it continuously hurls into space.

Dr. Bethe developed this theory by using the calculations of Sir Arthur Eddington for the temperature inside the sun. Dr. Bethe knew that 15 million degrees C. was much too high a temperature to be the result of a chemical burning reaction—such as fuel burning in a car or rocket engine. The temperature limit for such chemical burning is about 6,000 degrees Centigrade. The chemical bonds between the atoms simply do not contain enough energy to create higher temperatures.

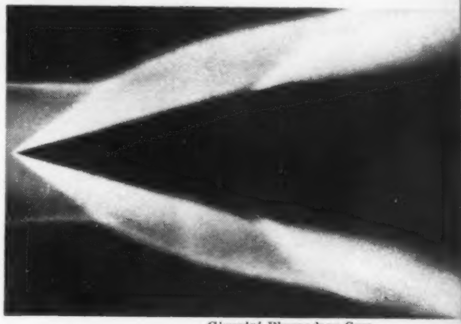
Above 6,000 degrees C., atoms no longer hold on to each other. In their violent random motion, all the molecules break up into individual atoms. Even the most heat-resistant materials, such as firebrick, are vaporized into gas. The collisions between atoms jar the electrons loose from their orbits. The gas becomes a mixture of free electrons, positive



Boeing Airplane Co.

High temperature shock wave glows brightly as it travels down gas-filled tube. Gas may reach temperature of 1 million degrees C. for three or four microseconds. Shock wave is created by discharging huge bank of electric capacitors through section of gas-filled tube. Wave may travel at speeds as high as Mach 250, 250 times speed of sound, or 275,000 feet per sec.

Photo below **shows missile model in tube of hot high-speed gas. Shock waves can be seen starting at the tip and the bends of the wedge.**



Giannini Plasmadyne Corp.

ions, and neutral atoms. Such a gaseous state of matter is called a *plasma*. At such temperatures solids, liquids, and gases cease to exist as we know them.

Dr. Bethe knew that in the sun's plasma the stripped atomic nuclei traveled at very great speeds. He reasoned that occasionally they would crash into each other. In such a collision, thermonuclear fusion occurs, the same nuclear process that takes place in the hydrogen bomb. In the sun, four hydrogen nuclei are transformed into one helium nucleus, with carbon occurring as an intermediate element to carry out the reaction. Therefore he called this process the "Carbon Cycle."

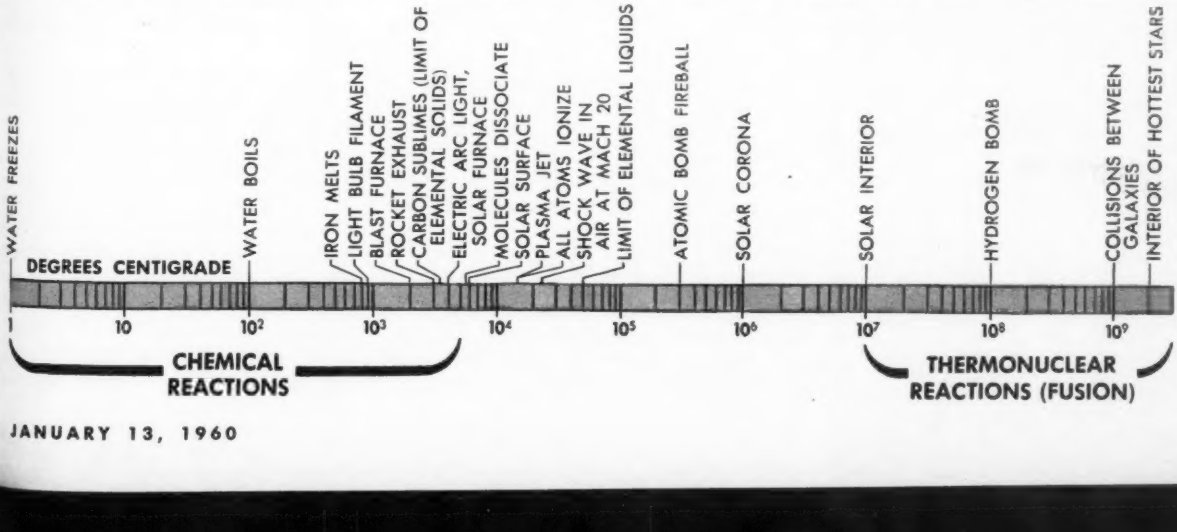
As the four hydrogen nuclei combine into one helium nucleus, they lose 1/100th of their mass. This mass is converted into energy. According to the theories of Dr. Albert Einstein, a little bit of mass will be converted into a tremendous amount of energy. In fact, Einstein's equation states that the energy produced is equal to the loss of mass times the *square* of the velocity of light ($E=mc^2$)—a very big figure. The conversion of only 100 tons of hydrogen into helium creates more energy than is used up by all of humanity in one year.

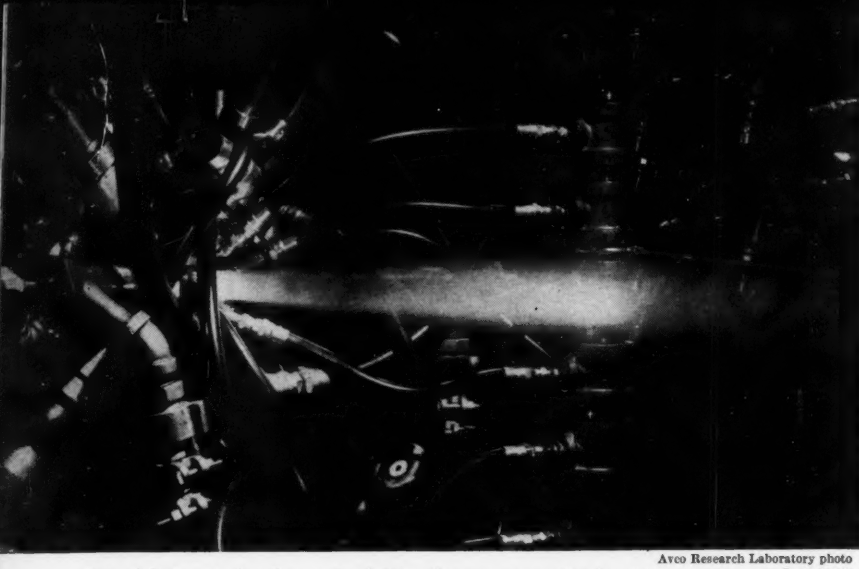
Such a conversion of hydrogen into helium is called a thermonuclear reaction (from *thermo*, meaning heat, plus *nuclear*). It can occur only at high temperatures, where all matter exists in the form of plasma.

Measuring Heat in Stars

The sun creates such high temperatures by the pressure of its own mass. The outer material of the sun presses on the inside with such force that the temperature rises to millions of degrees. This effect of pressure is familiar to anyone who has ever used a bicycle pump. After pumping a while, the pump may get too hot to touch.

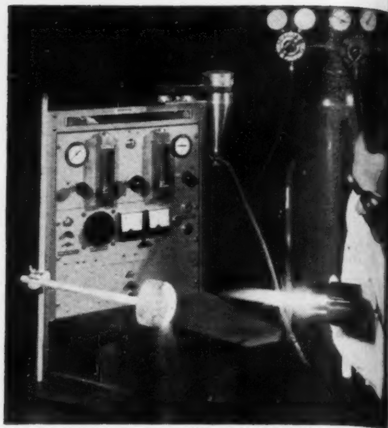
Similarly the Earth's crust and outer shell press on the inner core with such pressure that the rocks inside the Earth become a hot molten mass, forming the core. The molten rock from the Earth's core occasionally erupts to the surface through volcanoes, in the form of lava (*see pp. 5-7, this issue*). Fortunately, the mass of the Earth does not create internal temperatures high enough for a thermonuclear reaction to take place. If it did, the Earth would turn into a small star.





Avco Research Laboratory photo

Jet of hot gas shooting out of this plasma generator is at temperature of 8,000 degrees C.—higher than surface of sun. The jet is created by 10 million-watt electric arcs. The vertical pipe supplies water to keep generator from melting.



Ginannini Plasmadyne Corp.

Plasma jet gun vaporizes heat-resistant substances, coats them on rocket parts to keep them from melting on re-entry.

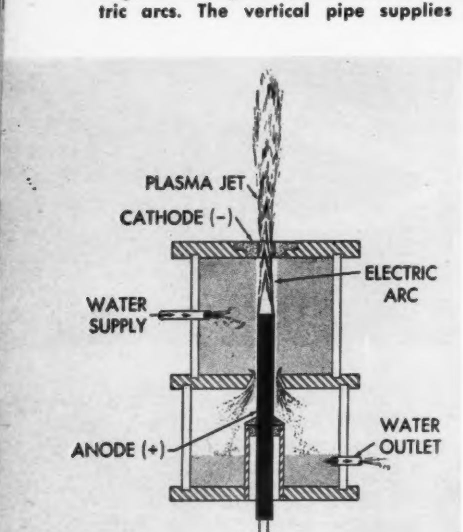


Chart from Astronautics, American Rocket Society

Principle behind electric arc plasma jet generator. Arc is struck between center rod and the ring in top disk. The water keeps the electrodes from melting.

Working with these concepts, Dr. Bethe calculated that the sun's conversion of hydrogen into helium was occurring faster and faster. He computed that the sun would grow, and then, as the carbon and hydrogen were used up, would shrink into a new type of star. This star would have a different type of thermonuclear reaction and would give off an intense blue light.

Astronomers have observed a similar development in the brightness and temperature of other stars. Some stars have shown tremendous increases in brightness within a short period, followed by a sudden return to their previous state. Astronomers have measured the changing temperatures of such stars by measuring the heat energy which the star radiates. The Stefan-Boltzmann law states that the energy radiated by a body is proportional to its temperature to the fourth power (that is, its temperature squared twice). For example, a white-hot iron bar radiates more energy than a red-hot bar because it is at a higher temperature.

By placing a heat-sensitive device, such as a thermocouple, at the focus of a telescope aimed at a distant star, astronomers can measure the amount of energy its radiates. With this measurement of radiated energy they can use the Stefan-Boltzmann law to calculate the temperature of the star. Observed changes in the temperature of several stars coincide with the changes predicted during the evolution of the sun.

Compared to the temperatures with which we are familiar, the temperatures inside the stars seem fantastic. And yet, ever since the hydrogen bomb was exploded, there is the possibility of creating such temperatures in the laboratory. Scientists reason that if a little bit of the sun's plasma could be made in the laboratory—and controlled—man would have an almost inexhaustible source of energy.

To achieve this, scientists have begun to study plasmas, the state in which matter exists at very high temperatures. Much to their surprise, they realized that they had been using plasmas all along.

Plasma is present whenever electricity is passed through a gas. It consists of charged particles which transport the electricity through the gas. Thus the blinding light of an electric arc is given off by a plasma, as is the luminous glow of a neon tube, or a fluorescent lamp.

But all these devices operate at relatively low temperatures, where only a small percentage of the atoms are ionized. Real plasmas begin at about 12,000 degrees C., when many of the atoms are ionized. At that temperature all the electrons have been torn from the atomic nuclei.

Plasma in a Shock Tube

Such temperatures are created by a rocket moving at many times the speed of sound (760 miles per hour at sea level). The shock wave that travels with the rocket through the air, the well-known "sonic boom," is actually an 11,000 to 28,000 degree C. plasma. Similarly, a meteor passing through the Earth's atmosphere creates a glowing plasma that marks its wake.

However, it's hard to carry out experiments while riding the nose of a rocket. Therefore, scientists are trying to create and control such temperatures in the laboratory. One way of achieving high temperatures has been with solar furnaces. A solar furnace is simply a big curved mirror which focuses the sun's rays. But one of the largest solar furnaces, located in France high in the Pyrenees Mountains where the sun shines bright and hard, reaches a temperature of

only 2,500 degrees C. By comparison, the exhaust of a rocket motor has a temperature of about 3,000 degrees C. A rocket motor generates about the highest chemical fuel temperature we can achieve. Higher temperatures can be created only by using plasmas—where chemical bonds between atoms no longer exist.

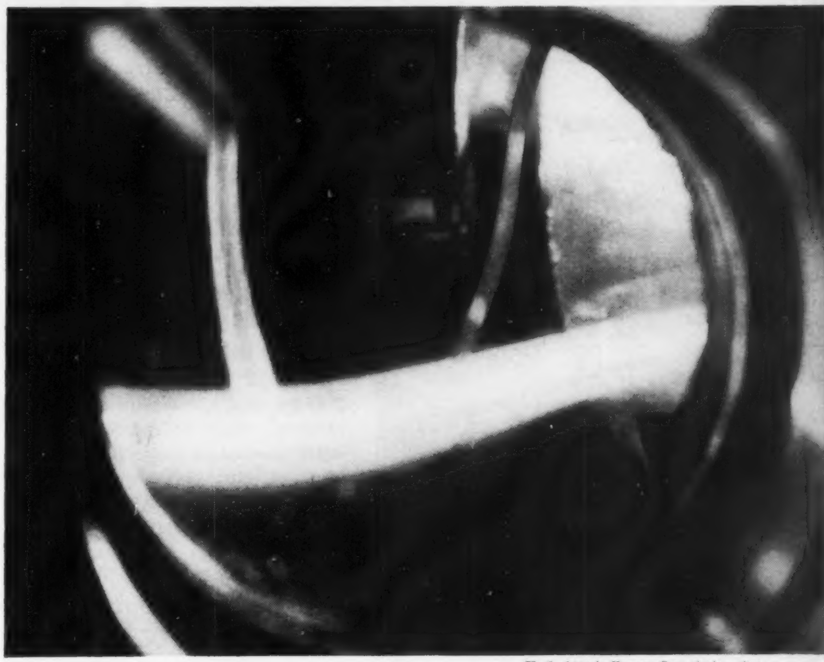
One method of making a hot plasma has been to use a shock tube. This device creates the same kind of shock wave that is found at the nose of a supersonic plane. The shock tube is between 10 and 40 feet long. The tube is separated into two parts by a metal diaphragm. The tube holds hydrogen on one side of the diaphragm, and some inert gas, such as argon, on the other. When the hydrogen is mixed with oxygen and exploded, the diaphragm bursts, and a shock wave travels down the tube filled with argon. The gas in the shock wave is so highly compressed that it becomes extremely hot. When this shock wave hits anything stationary (such as the model of a nose cone), it is compressed still further. This raises it to even higher temperatures. A shock wave traveling at the speed of Mach 20 (twenty times the speed of sound) will heat air to about 6,000 degrees C.—the temperature of the sun's surface.

(According to a law attributed to Jacques A. C. Charles—1746-1823—a French physicist, when the pressure of a gas is raised, its temperature increases. Charles' law together with Boyle's law describe the behavior of gases.)

The Plasma Jet Stream

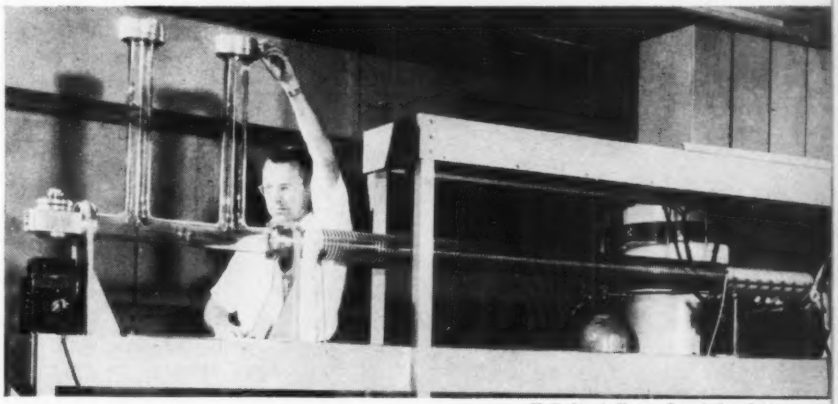
However, a shock tube can provide only single bursts of high-temperature gas. The first steady high temperature "flame" was created only a few years ago, by a device called a plasma jet. It creates a jet of hot ionized gases (a plasma), at temperatures higher than 15,000 degrees C.—more than twice that of the surface of the sun and five times higher than a rocket motor's exhaust. The plasma jet has the highest steady temperatures ever made by man.

The plasma jet is actually a special type of electric arc. It has a cooling system to keep the electrodes from being completely vaporized at the ultra-high temperatures. One elec-



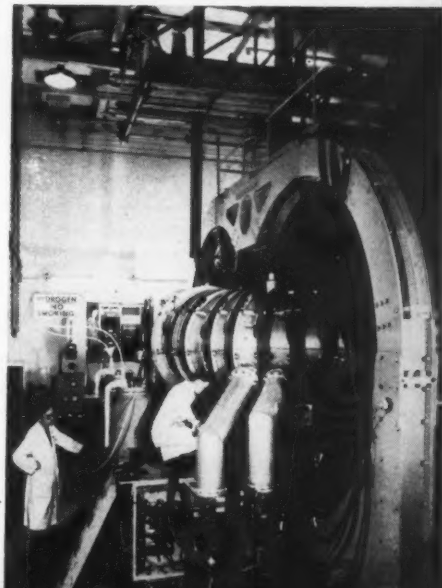
U. S. Atomic Energy Commission photo

Experimental thermonuclear fusion machine, showing intense carbon arc glowing like a hot wire. The gas in the arc is broken up into atomic ions due to the high temperature. The flowing ions are held in a glowing stream by a magnetic field.



U. S. Atomic Energy Commission photo

This machine accelerates hot ionized gas or plasma down the length of the tube. The coil of wire around the tube heats the gas with its magnetic field. Hot gas strikes the pendulum, at left, which measures the speed and energy of the gas.



Zeta, a British machine for creating controlled thermonuclear fusion. The hot gas flows in the large horizontal tube. The hydrogen gas is "pinched" in the center of the tube by magnetic fields. The magnetic fields are created by wires wrapped around the tube. Two arms sticking out of tube lead to two high-vacuum pumps.

British Information Service

Photo from Mount Wilson and Palomar Observatories
Plasma in the heavens. A filament of glowing gas in constellation of Cygnus.

trode of the plasma jet is a carbon rod. The other electrode is a carbon disk with a hole in it, facing the top of the rod. A cylinder encloses both electrodes. Water and a gas flow inside the cylinder to cool the electrodes.

When the switch is thrown and the arc is struck, the gas becomes highly ionized. The stream of positive ions flows toward the disk-shaped electrode, which is negative. This stream of ions tends to squeeze itself together into a tight jet. This is in accordance with a phenomenon identified by Michael Faraday more than a century ago. Two parallel wires with current flowing in the same direction will be attracted to each other by the magnetic fields set up by their current.

In fact, a thin stream of very hot gas behaves just like a wire carrying current. The stream of ions in the hot gas acts as an electric current. The ions are attracted toward each other and flow in a tight thin bundle toward the disk electrode, and out through its center hole. The result is a foot-long jet of high-temperature plasma, too brilliant to look at with the naked eye.

The effect of a stream of hot plasma being squeezed tighter and tighter as it flows along is known as the "pinch" phenomenon. Scientists hope to use this pinch effect to make hydrogen plasma with temperatures of millions of degrees—the same temperatures that exist in the interior of the sun and stars. If this is achieved, it will be like bottling a bit of the sun's interior in the laboratory.

"Magnetic Bottle"

These scientists are faced with one important problem: How to make a bottle which doesn't vaporize at such high temperatures? Or, more important, how to make a container that won't cool the plasma to the point where a thermonuclear reaction can no longer occur? To do this, scientists in many countries are now developing a "magnetic bottle" to hold the high-temperature plasma.

One form of this magnetic bottle is a simple tube, surrounded by a coil of wire, with an electrode at either end. The plasma flows down the length of the tube from one electrode to the other. The pinch effect keeps the plasma in the center of the tube, away from the walls which would cool it. The coil of wire around the tube creates a magnetic field which further squeezes the plasma.

This additional squeeze is possible because a stream of hot gas, as we have seen, behaves like a wire carrying current and can be affected by a magnetic field. This is spectacularly illustrated in an astronomical mass of hot gas, such as the sun. During explosions on the sun's surface, the tongues of hot gas erupting from the surface follow the sun's magnetic lines of force.

Similarly, the coil of wire around the magnetic bottle creates a magnetic field which forces the plasma into a tight thin stream. This raises the pressure and temperature inside the plasma even further. If the temperature were high enough, a thermonuclear reaction would take place.

The temperature of the plasma is also increased by the current passing through it. The higher the temperature, the better a conductor the plasma becomes. More and more electrons are knocked from the atoms, so that many loose charged particles float around in the gas, free to conduct electricity. A very hot plasma may be a better conductor than even copper. By pushing more current through plasmas for higher temperatures, and squeezing the gas still further with stronger magnetic fields, researchers plan to create controlled thermonuclear fusion.

Recently a magnetic bottle experiment was carried out in a machine dubbed Zeta, located in Great Britain. The British scientists had built the biggest bottle so far—a tube one foot in diameter. Huge banks of condensers were ready to unleash electricity of lightning proportions through hydrogen gas. A magnetic field around the tube would squeeze the plasma together. The scientists had apparatus ready to detect neutrons. They had calculated that if free neutrons showed up, the plasma would have reached the temperatures of thermonuclear fusion.

They pulled the switch. Neutrons appeared. Zeta seemed to be working.

Man's Own Sun on Earth

The scientists were jubilant over their apparent success. Then they had some sober afterthoughts. True, neutrons had appeared. But not as many as had been expected. A check of Russian and American results with similar machines showed that they, too, had created neutrons.

This seemed too good to be true. But a more careful check showed that another machine, which had not even been designed to create fusion, had also produced neutrons. Hurried calculations were made. The results showed that the neutrons of Zeta and the other machines had not been produced by really hot plasma. Instead, they were created by occasional high-speed collisions between ions.

Scientists in all three countries are undaunted by this first failure. They are continuing fusion experiments. It may be that in the future—5, 10, or 50 years from now, temperatures of hundreds of millions of degrees will be achieved in a machine like Zeta. At that time, man will have made his own sun on Earth.

By RICHARD BRANDT

The body has built-in defenses to throw back invasions by bacteria

IMMUNITY—Shield Against Disease

THE human body has a set of defenses to resist foreign particles seeking entrance into the body.

First among these defenses is the skin. Unless broken, the skin prevents disease germs from entering. And should disease germs be swallowed, chances are that the hydrochloric acid secreted by the stomach will destroy them.

Suppose bacteria penetrate into the tissues and blood through the nose or throat, or through a break in the skin. Here they encounter the body's second line of defense—the macrophages. Macrophages line the walls of the blood vessels of the bone marrow and liver. They also circulate in the blood. Like the white cells (leukocytes), the macrophages ingest bacteria. In most instances they are strong enough to destroy organisms invading the body.

What happens when bacteria break through the first two lines of defense? The infection then spreads. Bacteria, or the poisons they produce, are transported by the blood throughout the body.

An immediate reaction takes place between the bacteria (and their poisonous products) and special substances produced in the lymphatic system. These substances, known as *antibodies,* tend to destroy the disease germs or to neutralize their poisons.

The "Pattern" of Immunity

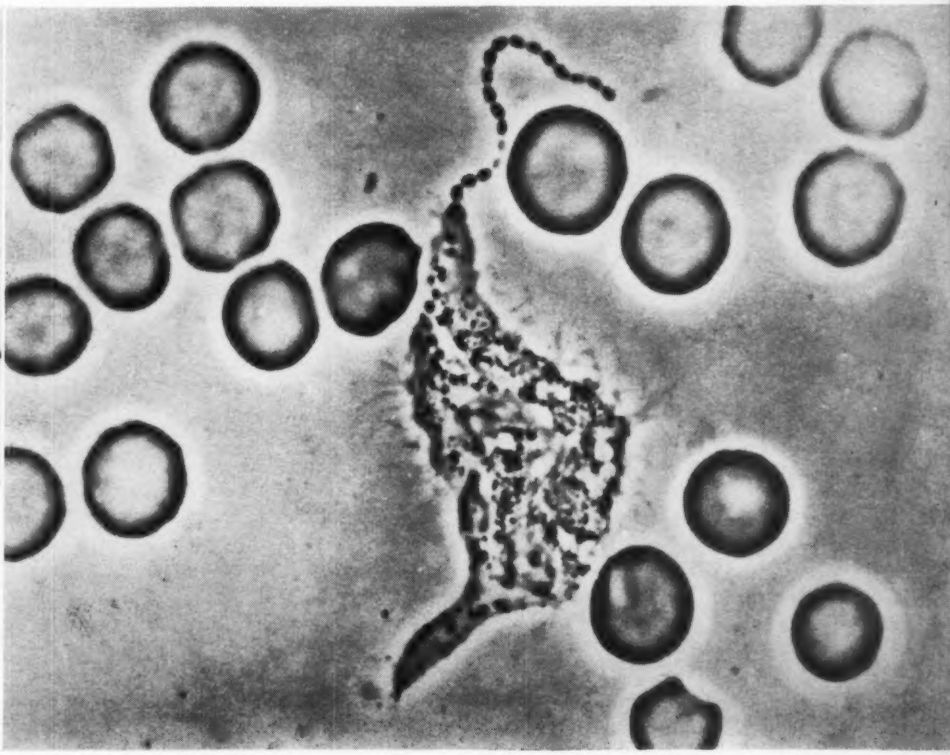
The existence of immunity in some form had been suspected since ancient times. For example, people knew that they didn't have to worry about mumps or chicken pox if they already had "caught" these diseases.

It was also known that some diseases occur in two forms—one mild, the other active and virulent. Infection by the mild form, it was found, provided immunity against the virulent form. In 1796 Dr. Edward Jenner used this knowledge to prepare the first successful vaccine against smallpox. He used a mild form of the disease known as cowpox to produce immunity against smallpox.

Scientists have found that the introduction of vaccines (*damaged* or even *killed* disease bacteria or viruses) into animals may provide immunity against the corresponding *living* organisms. Such a vaccine is the Salk vaccine for polio (*see Sept. 9 issue*). Polio virus is killed by being subjected to the chemical formalin. The reproductive ability of

Schering Corp. photo

Above — Photomicrograph of fungus. Fungus usually enters the blood through break in skin.



Chas. Pfizer & Co. photo

***Right*—Photomicrograph shows white blood cell *(center)* ingesting and destroying streptococci germs. White cell engulfs bacteria same way amoeba engulfs its food. Note red blood cells lack nuclei.**

the organisms is destroyed without harming ability to cause immunity.

The immunity process is still a puzzle to scientists. Laboratory experiments reveal that injections of "foreign" proteins (proteins not normally living within the animal) result in the formation of antibodies. These antibodies react with the foreign proteins. Foreign proteins which give rise to such antibodies are known as *antigens*. They include bacteria, protozoa, molds, and all other foreign protein substances.

Antibodies are specific. Thus one kind of antibody is effective only against a specific organism or against its specific products. Researchers also know that a definite quantity of antibody will react with a definite quantity of its corresponding antigen—and that it will not react with any other antigen.

Antibodies are made in cells of the lymphatic system, located in various parts of the body. The fluid in lymphatic vessels transports the antibodies into the blood.

Exactly how the antigen influences the manufacture of the antibody is not known. Dr. J. A. V. Butler, professor of physical chemistry at the University of London, offers several interesting hypotheses. Among them is this one: "Since the antibodies are all proteins of a similar nature, they are kept in a semi-fabricated state, like suits of clothes in ready-to-wear tailoring shops, waiting for the final touches which will insure an exact fit, to be put on in the *presence* of the antigen."

In diseases such as smallpox or mumps, where immunity may last for a person's lifetime, scientists theorize as follows: If the antigen has to be present when the antibody is formed, then it is reasonable to assume that the antigen acts as a "pattern" that remains in the tissues.

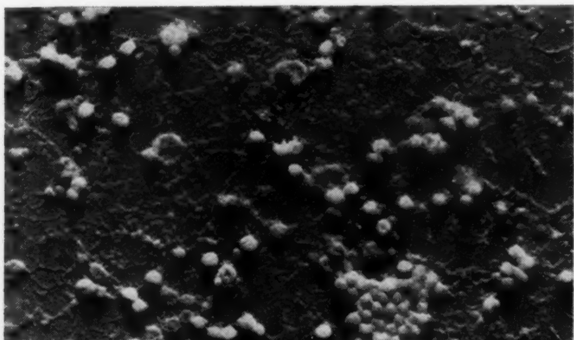
Antibodies—"Tailor-Made"

In 1957 scientists of the United States Public Health Service performed an ingenious experiment. They measured the rate at which human tissues manufacture antibodies against disease organisms. This was done by transplanting from one person to another the lymph node system in which antibodies are produced. (The lymph nodes are gland-like structures arranged in groups scattered throughout the lymphatic system.)

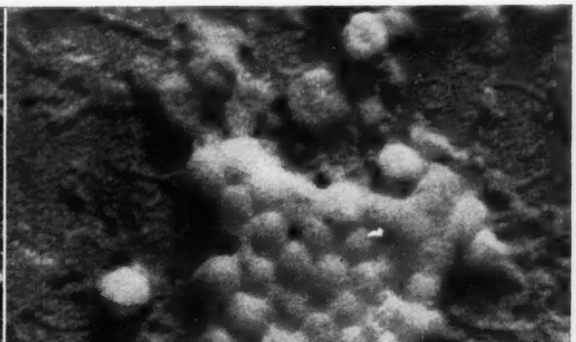
Dr. C. M. Martin and Dr. N. B. McCullough of the National Institute of Allergy and Infectious Diseases, working with Dr. J. B. Waite of the National Cancer Institute, selected a patient who had a rare disease, hypogammaglobulinemia. This disease is characterized by a lack of antibodies. Thus the scientists were able to measure the production of antibodies, once a system for manufacturing them had been transplanted. Patients with this disease tolerate transplants that would deteriorate in a *few* days in normal people. Furthermore, transplantation of the lymph node system, the doctors theorized, would be beneficial.

After the transplantation, the patient was given injections of typhoid vaccine. This was done on the seventh, fourteenth, and twentieth days after the transplant. The patient responded to the injections by producing typhoid antibodies. The lymph nodes that had been transplanted were carrying on a function the patient's own system had been unable to perform—they were producing antibodies against germs.

The scientists observed the levels of antibodies produced and divided these by 845 milligrams, which was the weight of the transplanted tis-

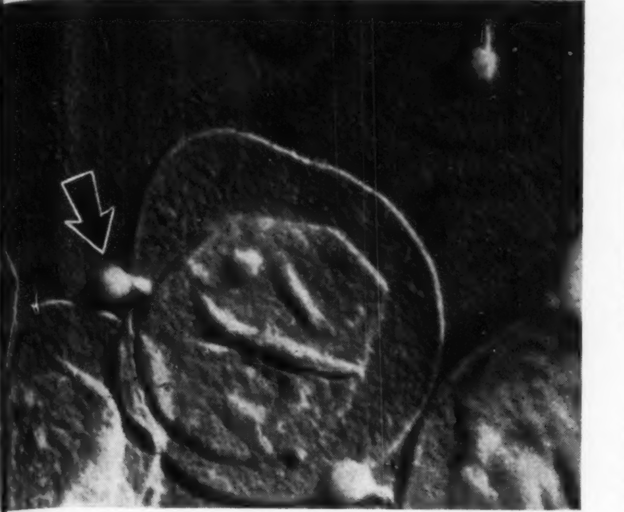


Above is electron micrograph of Influenza Virus, Type B, magnified 40,000 times. Virus enters body only through nose and mouth. Viruses are inert, but reproduce in living tissue.

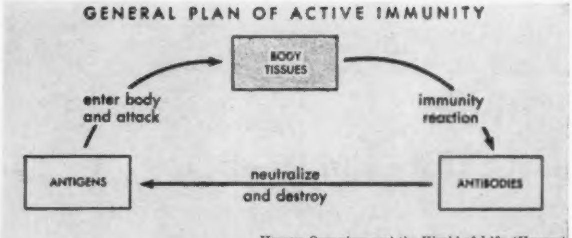


Photos from Lederle Laboratories

Group of viruses in photo at left is magnified 122,000 X by electron microscope. Single virus is giant molecule, but photo like above can be taken only with electron microscope.



National Foundation photo



Human Organism and the World of Life (Harper)

Diagram above **illustrates immunity cycle by which we produce antibodies to resist invasion of body by foreign proteins, called antigens. Antibodies inactivate the antigens.**

At left **is rare electron micrograph of viruses invading bacterial cell. Viruses *(arrow)*, the small pear-shaped objects, use their tiny protruding springs to inject chemicals that destroy the cell. This is one way in which bacteria are destroyed. Exact process by which antibodies work is unknown.**

sue. Thus they obtained a series of values for each day. This was the first direct measurement of the rate at which human tissue manufactures antibodies in the blood.

What do the findings suggest? Human lymphoid tissue normally responds with remarkable speed, production capacity, and versatility to challenge an invading organism. It can "tailor make" antibodies of various "patterns" to meet different challenges as quickly as other tissues produce enzymes and hormones.

Drawbacks of Immunity

Production of antibodies not only explains immunity; it also serves to explain another puzzling phenomenon. This is the phenomenon known as allergy, which also illustrates a drawback of the immunity process.

If you have hay fever or rose fever, you are well aware of the effects of an allergy. Let us suppose that you are allergic to ragweed pollen, a foreign protein. In your blood are antibodies which respond to this protein. Every time you expose yourself to ragweed pollen, a reaction takes place which causes you to suffer as if you had an infection.

An allergic reaction is only one of the harmful effects of the immunity process. Another drawback is revealed when surgeons try to graft skin from one human being to another, or from one animal to another. The grafts take hold and grow for a short while. But they soon wither and fall off. Repeated grafts between the same subjects never take hold. They are completely destroyed in a short time. After the first attempted transplant, the subject is immune to others. The body produces antibodies which react with the grafted skin (a source of foreign protein). After the first grafting, these antibodies are already in the blood. Another try at grafting results in an immediate reaction.

What is the substance in the foreign tissue that causes immunity? There are various hypotheses. Scientists generally theorize that only living cells can call forth the immunity response. But three British researchers, R. E. Billingham, L. Brent, and P. B. Medawar, have recently uncovered an important clue.

Their research indicates that *killed* cells can cause an immunity reaction, and that the active agent in this process can be traced to the nucleus of the cells. Using a process involving very rapid vibration, they broke up and separated the cell nuclei from cytoplasm in tissue samples. Injecting the nuclei into mice, they found that the nuclei produced immunity. The same procedure using cytoplasm did not produce immunity.

Next, an enzyme which digests desoxyribonucleic acid (DNA) was found to destroy the power of the nuclei to produce immunity. Other enzymes did not affect the potency of the immunity—producing material in the nuclei. The tests indicate a compound of DNA and protein may be the active agent in the immunity process. Does the activity actually reside in the DNA itself? Further research may provide the answer.

Reaction to Foreign Genes

Graft rejection, as we have seen, is able to make a distinction between the different *individual* members of a species. But this does not hold true in the case of identical twins. This is the only instance in which skin grafts can be transplanted.

Why is the immunity process apparently able to distinguish between distinct individuals? Practically every human being is genetically different from all others—except in the case of identical twins. Identical twins arise from one fertilized egg. Thus they have the same genetic makeup.

Of course, this has been known for a long time. The *new* finding is that antibodies respond to differences of genetic makeup among individual members of a species. Whenever a *foreign gene* (present in a skin graft, for example) enters the body, an antibody reaction occurs. This is another example of how the human body rejects foreign proteins.

We have seen the efficiency with which the human body resists foreign proteins, and some of the drawbacks of this reaction. But what would happen if this process were to break down, if even one phase of the process went astray? The result would be a defenseless organism open to attack by the parasitic bacteria and viruses surrounding it.

Science in the news

Beat from the Deep

Scientists have succeeded in making a cardiogram of the largest known heart, that of the whale.

9:30 p.m., December 5, 1959, Woods Hole, Mass.: Frantically, Dr. John Kanwisher of the Woods Hole Oceanographic Institution knocked on the door of his neighbor, Dr. Alfred W. Senft of the Marine Biological Laboratory. The door opened and Dr. Kanwisher announced that a whale was grounded at Provincetown and it was still alive.

Here was the chance for which scientists had been waiting. For 45 years, the famous heart specialist, Dr. Paul D. White of Boston, Mass., had tried to compare the performance of a whale's heart with that of a human's. Each time circumstances had prevented him from accomplishing his task.

The opportunity had come. Dr. Kanwisher sped 75 miles from Woods Hole to Provincetown. Dr. Senft hurried to his laboratory, where he sharpened some welding rods and wired them to make electrodes. It was 4 a.m. when he packed a standard cardiograph and the electrodes into his car. At 6:30 a.m. he arrived at Provincetown, where Dr. Kanwisher had spent the night on the beach in a sleeping bag. High water prevented any work at that time.

The cardiograph was fitted with a 100-yard electric lead and plugged into a nearby ice-cream parlor outlet. Six or seven electrodes were stuck about eight inches through the 50-ton whale's blubber. "We got our first cardiogram a little after 8 a.m. We got eighteen cardiograms before stopping a little after noon."

The cardiograms showed a pulse beat of 25 per minute and the estimated relative size of the heart as about 500 pounds. The human pulse beat is approximately 72 per minute and the heart weighs about half a pound. Dr. Senft reported that "now, for the first time, we know for sure that what we suspected is true. The whale heart is pretty analogous to the human heart."

As the cardiograms were made, Dr. Kanwisher obtained temperature measurements and collected respiration samples from the whale's blowhole. The whale had an internal body heat of 92 degrees F., while the fins and tails had a temperature of 50 degrees F. The dorsal fin was much warmer. Gas samples taken from the whale's breath showed that the animal's lungs were not functioning well. The whale extracted only 1/3 as much oxygen from the inhaled air as human's do.

Since a whale's slow heart beat is less difficult to analyze for signs of disease than that of other animals, scientists now know that information gained from a whale can be applied to human beings. Now they must "get a cardiogram from a healthy whale at sea," says Dr. White.

As for the whale who will go down in medical history, it could not be saved. Efforts by the Animal Rescue League to keep the whale moist (a dried whale does not live long) and by the U. S. Coast Guard to tow him out to sea failed five times. As many whales before him, he wanted to go on the beach and no effort could stop.

Polio Virus Portrait

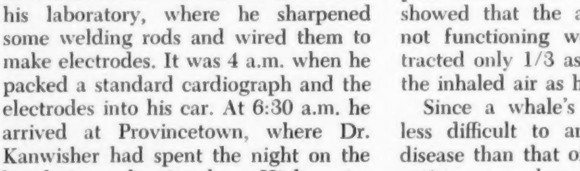
For the first time, polio viruses have been observed and photographed inside the human cell in which they were formed.

This achievement has made it possible to correct some mistaken beliefs about polio virus behavior and to seek the answers to some unsolved questions.

Dr. D. C. Stuart, Jr., and Dr. Jorgen Fogh of the New York State Department of Health found that the viruses apparently are formed in the cytoplasm surrounding the nucleus, not in the nucleus, or core of the cell, as had been supposed.

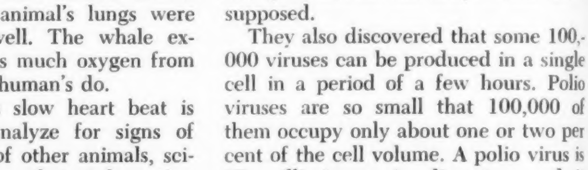
They also discovered that some 100,000 viruses can be produced in a single cell in a period of a few hours. Polio viruses are so small that 100,000 of them occupy only about one or two per cent of the cell volume. A polio virus is 27 millimicrons in diameter, and it would take almost a million lying side by side to equal one inch.

Human polio viruses previously have been seen under the electron micro-



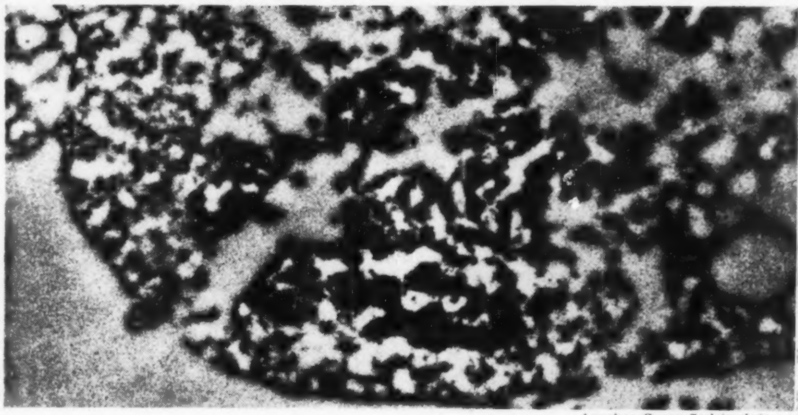
UPI photo

Oceanographers have field day. For first time, heart beat of large whale is recorded. Dr. Senft *(foreground)* removes cardiograph machine after taking successful readings from whale.

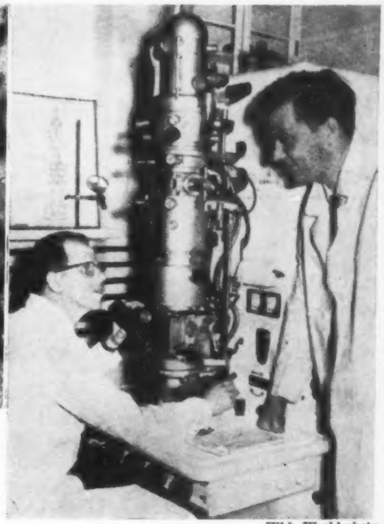


Woods Hole Oceanographic Institution

***Top*—Cardiogram of 44-foot fin whale's heart. *Below*—Cardiogram of Dr. Kanwisher. Widely spaced peaks of whale's cardiogram show 25 beats a min. Human heart shows 72 beats.**



American Cancer Society photo



Wide World photo

Another first in medical science. Photo above shows poliomyelitis viruses inside human cell in wnich they were formed. At right are Dr. Stuart and Dr. Fogh who used electron microscope to view honeycomb pattern of viruses. Scientists found that viruses are formed in cytoplasm surrounding nucleus, not in nucleus.

scope in isolated and concentrated form *outside* the cell. In 1955 Dr. Fogh and his co-workers devised a way of enabling human amnion cells to grow in laboratory dishes. Amnion cells are found in the placenta. They nourish and protect the fetus. Dr. Fogh, who is a virologist, and Dr. Stuart, an electromicroscopist, added polio virus to cultures of amnion cells. They then sliced the tiny cells as one would slice a loaf of bread, and made electron micrographs of the remarkable production of virus particles inside them.

The two research scientists found that the tiny polio virus clustered inside the cell. Although the biological, physical, and chemical properties of polio viruses had been studied extensively, this was the first demonstration of small viruses of any kind inside the living cell.

The scientists are currently attempting to capture on film one of nature's closely guarded secrets—the *actual* process of virus manufacture *inside* the cell.

These basic studies may throw light on how infections develop—and possibly how infections may be blocked. If cancer should turn out to be virus-caused, the findings may have application to this disease.

Pico, Nano, Tera

This trio of strange-looking words is a new addition to the language which scientists use in describing numbers, both big and little.

Tera is a prefix denoting one trillion, and nano is a prefix denoting one billionth. Thus, one trillion grams would be called a teragram, and one billionth of a volt would be a nanovolt.

The prefixes were recently adopted by the National Bureau of Standards, after a recommendation of the International Committee on Weights and Measures. They supplement other well-known prefixes in the decimal scale, such as kilo, micro, and centi. The complete list is given below, with the four newly-coined prefixes marked with an asterisk:

Multiple	*Prefix*	*Symbol*
$1\,000\,000\,000\,000 = 10^{12}$	tera*	T
$1\,000\,000\,000 = 10^{9}$	giga*	G
$1\,000\,000 = 10^{6}$	mega	M
$1\,000 = 10^{3}$	kilo	k
$100 = 10^{2}$	hecto	h
$10 = 10$	deka	dk
$0.1 = 10^{-1}$	deci	d
$0.01 = 10^{-2}$	centi	c
$0.001 = 10^{-3}$	milli	m
$0.000\,001 = 10^{-6}$	micro	u
$0.000\,000\,001 = 10^{-9}$	nano*	n
$0.000\,000\,000\,001 = 10^{-12}$	pico*	p

*Pronunciation: tĕr'á, jĭ'gȧ, nā'nô, pī'cô.

Life on the Planets?

Human beings on other planets? "Ridiculous," commented Professor Hermann J. Muller. There may be plant-like and animal-like life on other worlds, but it is unlikely that they resemble either us or our vegetation.

This was the opinion of an outstanding Nobel-Prize winner, who in 1926 discovered that X rays applied to living organisms such as fruit flies create a wealth of mutations. The X rays apparently change the genes in their chromosomes (*see page 20*).

Geneticist Muller spoke recently on the forms of life that might be found in the universe, at a meeting of the National Association of Biology Teachers. It is a good possibility that some form of life might be found elsewhere in the universe, he said. Its origin and development would probably approximate the rise of life on Earth.

The essential organic compounds necessary for self-reproducing life could be created in the atmosphere of other planets, in the way they are believed to have been created on the Earth.

After the first step, "the process of Darwinian natural selection will inevitably cause these primordea of life [primitive cells] to evolve into increasingly diverse types," he said.

"Higher organisms that have evolved on other planets may be expected to differ from the nearest terrestrial ones in their anatomy, outer form, internal economy, etc., at least as much as the diverse higher phyla on Earth differ from one another . . . Thus it is absurd to imagine other worlds with organisms classified as grasses, insects, mollusks, fish, reptiles, birds, or mammals, as many science fictionists have done.

"And to suppose that human beings have evolved there is about as ridiculous as to imagine that they speak English."

Other beings he said may have eyes similar to ours, since only a few types of eye are practicable. He also theorized that conditioning, association, and learning might arise and lead to intelligence and the use of tools.

Why have we not had visits from the inhabitants of other planets? They might not be able to get here from planets that are hundreds and thousands of light years away.

To sum up Professor Muller's speech: Don't expect to meet any Martians in the near future except in the movies or on television.

Science in the news

The Oldest Mummy

Just skin and bones—that's all that remains of the body of a child buried in the hot sands of the African desert about 3,400 B.C.

The body had been mummified before burial to preserve it from decay and from the elements. It is the oldest deliberately preserved mummy ever found, and is much older than the oldest Egyptian mummies.

The mummy was discovered in a prehistoric shelter deep in the Libyan desert by Dr. Fabrizio Mori, an Italian paleoethnologist (scientist who studies the rock drawings of ancient cultures). Dr. Mori was exploring the mountainous desert region, searching for inscriptions on rocks, when he discovered an ancient shelter at the foot of a cliff. He dug through the sand floor of the shelter, hoping to find the remains of prehistoric campfires, but instead he unearthed the mummy.

The body was that of a child. The mummy was bent double and had been wrapped in goatskin. It had been mummified by dessication (drying the tissues). The abdomen had been eviscerated and a sheaf of herbs placed inside the body. The use of herbs represented an attempt to mummify the body before burial.

The discovery showed that a simple system for preserving the dead had been in use long before the Egyptians developed their elaborate methods of mummification. The mummy is the oldest which shows signs of having been deliberately preserved. Older mummies have been discovered. However, these were accidentally preserved when a corpse was buried in the hot desert sands. The sand dried the corpse and protected it from the elements, preserving it through the centuries.

The age of the newly discovered mummy was determined by radiocarbon dating, which showed it to be about 5,400 years old. The radiocarbon method measures the amount of the radioactive isotope, carbon-14, in the bones. (The next issue of *Science World* will include an article on carbon dating.)

The oldest man-made mummies have previously been found in Egypt, dating from 3,000 B.C. The idea of mummification originated in prehistoric Egypt, where the dead were buried in the desert sands. The hot dry sand arrested the process of decay so that the hair, skin, and other soft parts of the body were preserved. This led the Egyptians to believe that the bodies of the dead survived. Accordingly, they began the practice of burying food, tools, and treasures with the dead, for use in their next life.

Eventually, to make room for all the burial objects, the dead were buried in larger graves. In a grave, however, the body came into contact with the air and decayed. To the Egyptians, this implied that the dead may not live on to enjoy the objects buried with them.

To maintain their ancient beliefs, the Egyptians tried to help nature preserve the corpse by mummifying it. Dr. Mori's discovery showed that this practice had been in use in other cultures, for some time before the Egyptians developed it, 50 centuries ago.

"Muscle Engine"

The forerunner of a "muscle engine" is the result of basic research at the U.S. Army's Frankford Arsenal.

A film made of organic materials, that contracts when it comes in contact with an acid and expands when it comes in contact with an alkali, provides the muscle in the "muscle engine." The same chemicals were used over and over again in demonstrations to make the muscle engine work.

Dr. Henry Gisser, James J. Mikula, and Joseph Weisburg are the scientists working on the project. In a demonstration, the contracting film was made to raise and lower a cardboard arm resembling the arm of a man. In other demonstrations, the film lifted small weights.

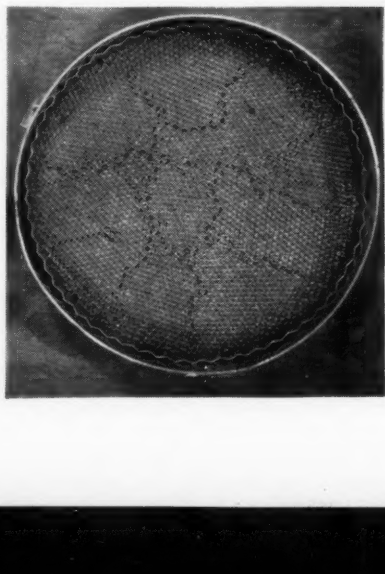
The aim of the project is to find a way to change chemical energy directly into mechanical energy without going through a heat cycle. The heat cycle imposes a limit on the efficiency that can be obtained. If the heat cycle could be eliminated, the efficiency for converting chemical energy into mechanical energy might be raised. (*Give you any ideas for a science project?*)

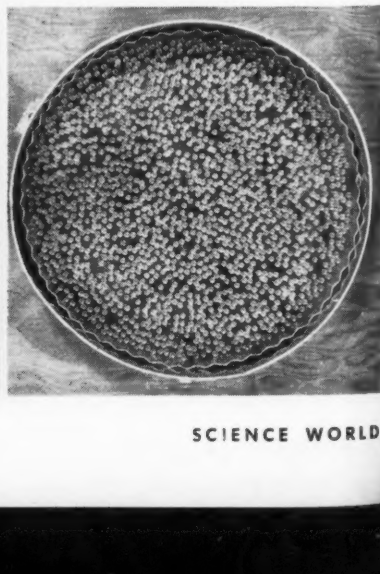
The research is officially called "synthesis of polyelectrolytes for contractile films." It is one of the Army's "novel engineering projects." Promising novel technical ideas in any area of ordnance engineering are granted limited funds, if early research shows that the idea has merit. In this case it proved so successful that further funds are to be spent on it in 1960.

Right—Marbles mimic behavior of atoms when thrown onto vibrating plate in General Electric lab. Plate is suspended by springs, moved at random by motor. Beads jump from hole to hole, imitating motion of atoms in solids, liquids, and gases.

Below—Hundreds of glass marbles loosely packed on jiggling plate *(at right)* jump around like atoms in liquid. They show no specific pattern. More closely packed marbles *(left)* simulate structure of solid, showing several boundaries between adjacent groups of the atoms.

General Electric photos





Longest Tunnel

Engineers are once again drawing up plans for the most ambitious tunnel construction project ever conceived—a 30-mile-long tunnel under the English Channel connecting England and France.

A team of British and French geophysicists, engineers, and economists has declared that the engineering problems could easily be solved, and that the tolls charged could make it profitable to both countries.

At present, the longest existing tunnel is the 12.3-mile Simplon tunnel, connecting Switzerland with Italy through the Alps.

The proposed tunnel would span the channel between Dover, England, and Calais, France, at the narrowest part of the English Channel. The tunnel would be drilled in a solid layer of chalk which stretches between England and France below the channel. The chalk bed, lying about 160 feet below the surface of the channel, is impervious to water. This would make drilling rather simple, even for a tunnel as long as 30 miles. Engineers say that the tunnel could be built in six years at a cost of about $300,000,000.

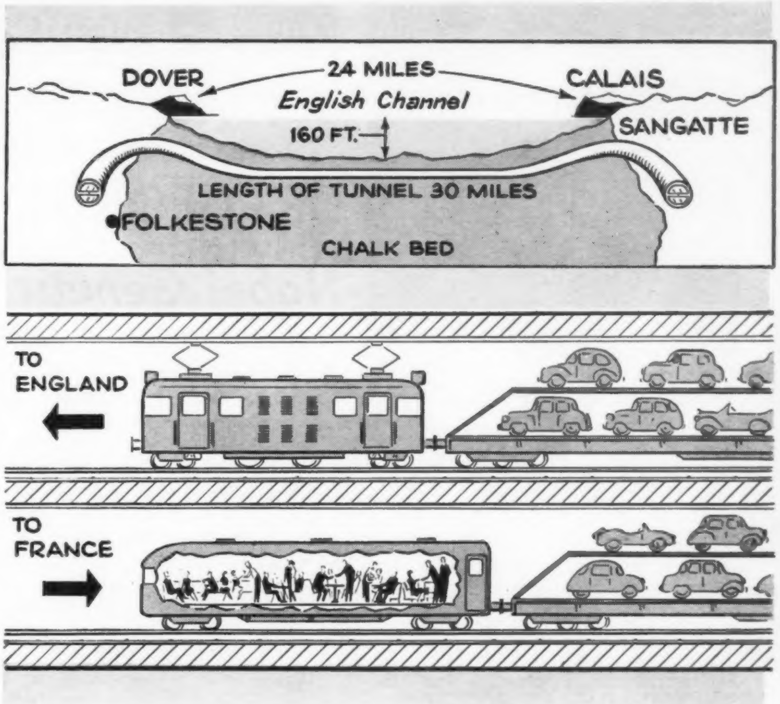
Test drillings from a boat in the channel have convinced geologists that the chalk bed stretches without a break from one side of the channel to the other. However, no one can promise that there is no break somewhere in the chalk layer. Geologists tell us that Britain was once part of the continent of Europe, connected by a neck of land. About 10,000 years ago the sea broke through the neck of land, and Britain became an island.

The report submitted to both the French and British governments discusses many early schemes for road tunnels, rail tunnels, and bridges designed to span the English Channel. The idea for a tunnel was first suggested to Napoleon Bonaparte in 1802, by Mathieu, a French engineer. In 1880 the construction of approach tunnels, called "galleries," was started on both sides of the channel. The British government suddenly pulled out of the project and the tunnel was never completed. Numerous other tunnel projects proposed since then have all foundered on the political rocks. Each country feared the other might use the tunnel for invasion.

Mathieu's plan called for horse-drawn carriages to provide transportation within the tunnel. The most recent proposal calls for a dual rail tunnel to carry electrically driven trains. The idea of a road tunnel for automobiles had to be discarded. Ventilating a 30-mile tunnel to remove gasoline fumes would have been very difficult and costly. In addition, the thought of auto breakdowns and the resulting traffic jams made engineers shudder.

The electric railroad would be designed with gradual curves and grades for high speed travel. As many as 100 trains a day would pass through it in each direction, at speeds up to 70 miles an hour. Automobiles and freight would be transported on railroad flatcars.

The tunnel would last indefinitely and would cost little to operate and maintain. The cost of the tunnel would be paid by the International Suez Canal Company, the same company which built the Suez canal joining the Mediterranean with the Red Sea.



Science World graphic

Tunnel under English Channel would "reunite" England and France, which once were linked by neck of land. About 10,000 years ago the sea broke through neck and Britain became an island. Channel tunnel would handle only electric trains. Auto traffic would make ventilation too expensive. Autos would be carried on flatcars.

Noise Stress Effects

Noise can really be upsetting, even to a guinea pig.

Laboratory rodents, subjected to high intensity noise for a long period of time, suffer a breakdown of their normal endocrine gland system.

Pennsylvania State University researchers found evidence of disease in the adrenal glands and other organs of lab rodents following weekly exposure of 20 to 40 hours of high intensity noise for two to nine weeks.

The animals huddled together, Dr. Adam Anthony, Dr. Eugene Ackerman, and Dr. James A. Lloyd report. Rats and mice froze into a rigid, motionless stance. Increased washing and grooming was also observed in the rats and mice. Guinea pigs did not resume their normal activities as quickly as did the other animals. This seems to indicate that they are more sensitive to noise than either rats or mice.

Mosquito "Blows" Out

Upon reaching adulthood a mosquito simply blows itself out of its pupal case.

The case is a tough little bag in which the pupa is transformed to an adult. It is during this stage that nerve control of flight is fully developed, along with the "mechanical apparatus," wings.

How does the mosquito do this?

Air is sucked into the mosquito's stomach, reports Dr. R. E. Snodgrass of the Smithsonian Institution. Eventually, the walls of the pupal case rupture and the adult mosquito emerges.

California Institute of Technology photo

today's scientists

DR. GEORGE W. BEADLE

Nobel Geneticist

THERE is no telling how far a teacher's influence may extend. Like many other great scientists, Dr. George Wells Beadle, Nobel Laureate, owes a great debt of gratitude to one of his high school teachers. "I thought I was going back to the farm," Dr. Beadle reminisced recently, "but Miss Bess McDonald had a great ability to encourage her students to go ahead. She talked me into going to college."

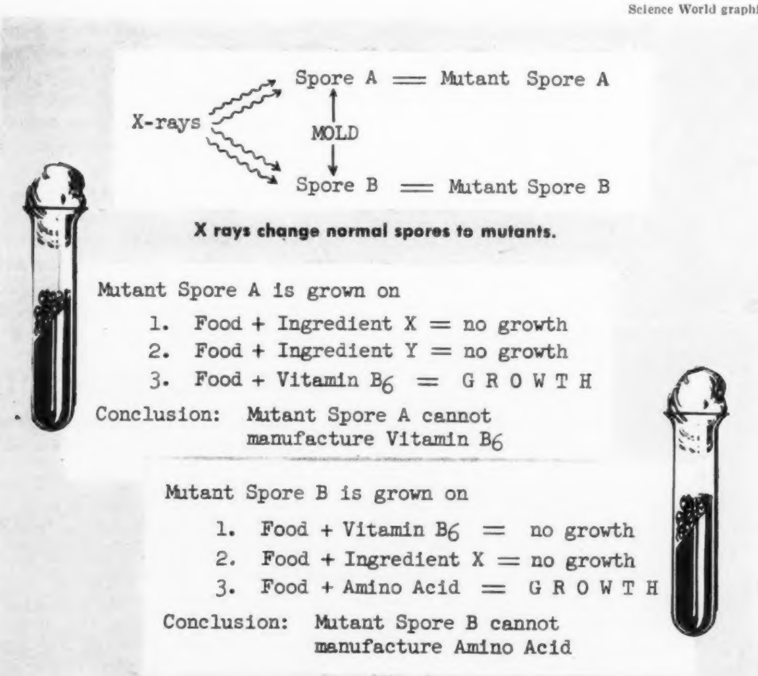
Dr. Beadle, world famous geneticist, might have been a farmer today if he had followed the path of least resistance. Dr. Beadle was born in 1903 on a small farm near Wahoo, Nebraska. His mother died when he was four and he was brought up by his father.

School meant a mile-and-a-half trek back and forth each day. Occasionally he earned some money keeping bees and trapping muskrats. What did he do with the money? He bought garlic bolognas for lunch, to replace the jelly sandwiches he brought from home. He dislikes jelly sandwiches to this day.

Genetics in Its Infancy

Wahoo was not especially an educational center 50 years ago, but one teacher, Miss McDonald, kindled a flame of enthusiasm for science in young George Beadle. Miss McDonald, a physics and chemistry teacher, persuaded him to enroll at the University of Nebraska's College of Agriculture.

Science World graphic



This is diagram of experiment Beadle used to find missing genes in mutants.

At the University of Nebraska, he became interested in genetics in the classroom of Dr. Franklin D. Keim. George Beadle helped Dr. Keim carry on experiments with hybrid wheat. When Beadle was graduated in 1926, Dr. Keim helped his promising student obtain an assistantship at Cornell.

In the 1920's, genetics was still in its infancy as a science. The outstanding geneticist was Dr. Thomas Hunt Morgan of Columbia University. He was known as the founder of the "fly school" of genetics. His experimental subject was Drosophila melanogaster, which is a long name for the tiny fruit fly found wherever fruit is present.

Fruit flies were excellent for use in a laboratory. They were small in size (only 1/12 inch long) and they produced new generations every two weeks. Storing them was no problem—small glass bottles stuffed with gauze provided them with a perfect environment for growth and development.

Dr. Morgan's studies of large fruit fly populations revealed some flies that were different. The differences were caused by changed genes. These changes were known as mutations. The mutations were inherited according to Mendel's law of heredity, just as you inherit the color of your hair or eyes.

Needed: A Simple Organism

Dr. Hermann J. Muller, one of Dr. Morgan's students, discovered that fruit flies—or for that matter any other living organism—exposed to X rays can be mutated. Apparently the genes were changed by X rays. Mutations created by X rays were found to be passed on to future generations. Like his teacher Dr. Morgan, Dr. Muller too won a Nobel Prize for his work.

In 1931 Mr. Beadle became Dr. Beadle and went to the California Institute of Technology on a National Research Council fellowship. Dr. Morgan was then director of the Division of Biological Sciences at the California Institute of Technology.

(Continued on page 28)

tomorrow's scientists

Project: A New Separation Process for Algae

Student: **Larry Dahlkvist**
Cubberley Senior High School
Palo Alto, Calif.
Science Achievement Awards Winner
Teacher: **R. B. Bartholomew**

[Practicing scientists are often ready and willing to help tomorrow's scientists with their projects. In Larry's case, Dr. J. P. Patterson not only introduced Larry to the problem of finding a separation process for algae, but also helped him obtain space at the Palo Alto Medical Research Foundation to do his work. The photographs and microphotographs are all Larry's work, including both printing and developing.

An inexpensive way to harvest algae is on the government's list of most wanted projects. Does Larry's work suggest ideas for more science projects?]

THE PROBLEM

The growth of the world's population (predicted to triple by the year 2000) will bring about many problems. Assuming that the problem of surplus farm products is only temporary, among the most important problems is the need for an ever-increasing amount of food products. As more and more human beings inhabit the earth, it could be that our arable land can't be made to produce enough food. Even today, with two out of every three persons in the world in a state of malnutrition, not enough food (assuming distribution problems could be solved) is being produced. This is the problem, and it may grow worse unless we can produce more food faster per acre of land—a clear cut problem being faced by today's scientists.

THE HYPOTHESIS

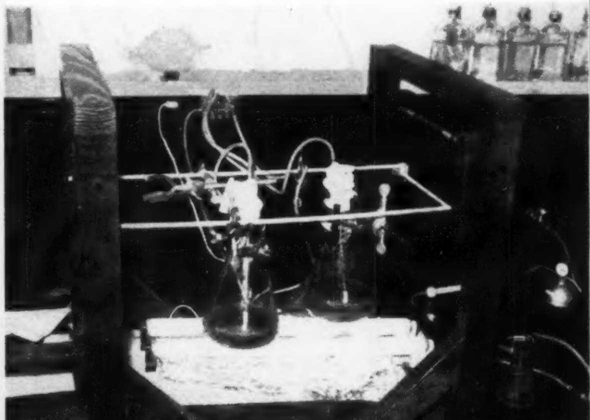
Here is some of the background information scientists have assembled:

1. A culture of algae can be maintained continuously and it will make use of the light on a year-round basis.
2. Algae can convert much more of the light they receive into stored energy than can farm crops.
3. Chemical analysis shows a much higher percentage of protein and fat in green algae than is found in any farm crop.
4. Algae have less waste material.
5. Algae can be produced at an average rate of 40 tons per acre per year while ordinary crops produce an average of only two tons per acre per year of edible material.
6. A cattle fodder can be produced at about two to six cents a pound.
7. Chlorella cells, a typical algae, can reproduce eight times in one day. In other words, one cell in a 24-hour period (assuming ideal conditions) can yield 64,000 mature cells.

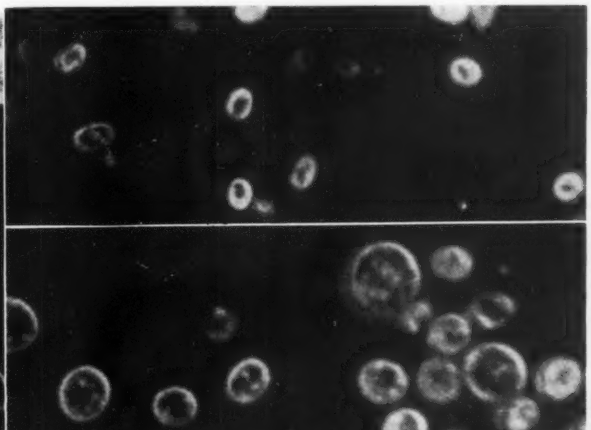
This background information almost automatically suggests an hypothesis to use in attacking the world food supply problem—*grow algae.*

DIFFICULTIES

Rarely, if ever, does a scientist's work proceed smoothly between his hypothesis and the solution to his problem. One of the major barriers to the production of algae as an economical animal fodder arises when we attempt to separate this microscopic plant from the nutrient solution in which it must be



Apparatus—Flasks with culture are supported over 60-watt fluorescent lamps. Each flask is fed 200 ml of air per min.



Photomicrographs made by Larry—Chlorella pyreniodosa (top) is magnified 1,000 X, as is Scenedesmus obliqus (at bottom).

grown. My project attacks this barrier.

Common sense told me that my first step should be to see what solutions other people have attempted, and to find out why they didn't work.

METHODS OF SEPARATION	DISADVANTAGE
Evaporation of water	Cost of energy is exorbitant
Alum flocculation	Damages value of algae
Centrifuge	Process is too involved and expensive
Settling tank	Inefficient, great deal of time required
Spray freeze drying	Not economical because of large amount of energy required. Cuts down food value
Filtration	Will not work. Range of cell size is too great.

Since each of these processes is either too expensive, inefficient, or damaging to the food value of algae, the problem remains to be solved. I needed a new working hypothesis.

SEARCH FOR WORKING HYPOTHESIS

Again, common sense tells us that the more we know about something, the more likely we are to make wise guesses about it. I decided to go back and study the whole life cycle of the algae, Chlorella.

The life cycle of Chlorella begins with the parent or mature cell. The parent cell reproduces itself by forming two or more autospores or daughter cells. The new cells then mature and repeat the process.

As the cells mature in a rich nutrient, they take from the water a large quantity of the positive ions—potassium (K), magnesium (Mg), iron (Fe), etc. When the positive ions are taken from the solutions, the negative ions remain. However, they remain only for a short time. It has been found that these negative ions collect on the cell wall, giving the cell a negative charge.

USING NEGATIVE CHARGE

The negative charge of Chlorella suggests a new working hypothesis. We might take a large tank and place within the tank two highly charged electrodes. It follows that the algae cells would separate from the solution and collect around the positive electrode.

Even though this method might work, the electricity would be expensive. There also are other likely problems: decomposition of nutrient by electrolysis, damage of the cell content, and contamination of the solution by the metal electrodes.

Within the past decade the Dow Chemical Co. has developed a product bearing the trade name Separan. This is a polymer (a chemical compound composed of long chains of carbon atoms) which can collect or flocculate positively charged metal ions from solutions.

Structurally this polymer is composed of long tentacle-like chains of negatively charged carbon atoms, which attract and hold the positively charged metal ions. Soon the weight of the polymer and metal increase to the point where they both sink to the bottom of the container. A simple filtration process completes the procedure.

Recently a polymer (polyelectrolite) was developed which has a positive charge and thus will attract negatively charged particles. Don't you see my new hypothesis shaping up—*use this polymer to separate algae.*

MY EXPERIMENT

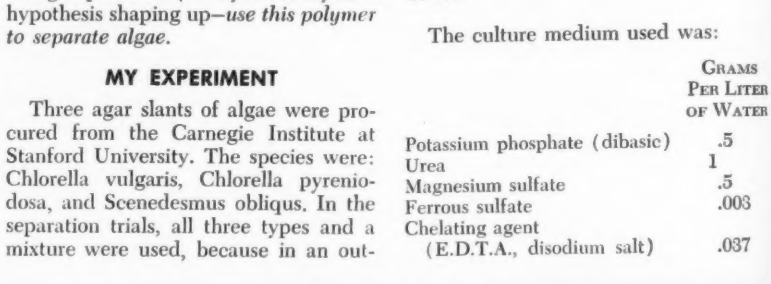
Three agar slants of algae were procured from the Carnegie Institute at Stanford University. The species were: Chlorella vulgaris, Chlorella pyreniodosa, and Scenedesmus obliqus. In the separation trials, all three types and a mixture were used, because in an outdoor mass culture many species will be used.

Four, two-liter flasks, containing approximately a liter of culture each, were supported over two, 60-watt fluorescent lamps. Each flask was fed with about 200 milliliters of air per minute. Cultures were continued for seven days or until the concentration reached 1,000 parts per million (ppm) dry weight of algae. In either of these cases, the old media were removed and a fresh culture started.

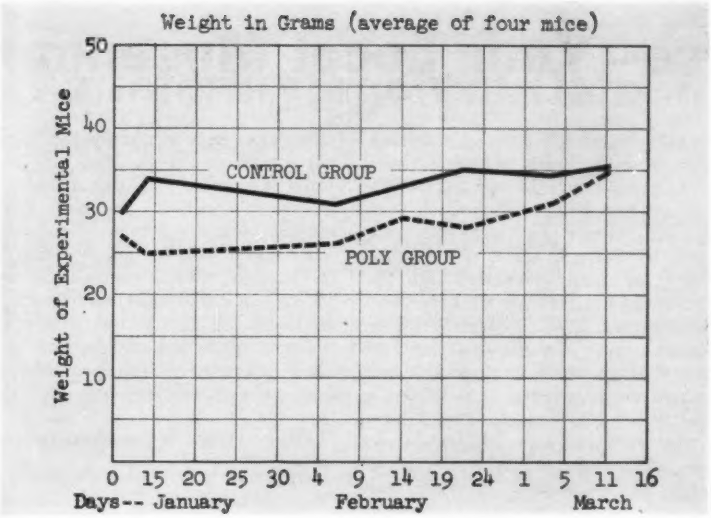
As is the case with so many experiments, I needed to measure accurately and easily several things. The spectrophotometer or colorimeter was used in my experiment to determine the concentration of the culture (ppm) and to determine the rate at which algae separates from a solution. The spectrophotometer measures the amount (per cent) of light a solution will transmit, thereby giving the concentration or optical density. If the solution is very dense, the percentage of light transmitted is small, and vice versa if the solution is not very dense.

The culture medium used was:

	Grams Per Liter of Water
Potassium phosphate (dibasic)	.5
Urea	1
Magnesium sulfate	.5
Ferrous sulfate	.003
Chelating agent (E.D.T.A., disodium salt)	.037



Floc of algae, clay, and Poly. Larry found Glauconitic clay shows most promise.



To find if Poly is harmful to animals, Larry fed mixture of Poly and lab chow to four white mice for two months, same food without Poly to control group (at top). He noted no difference in weight, reproduction, general well being.

Because of the buoyant nature of microscopic organisms such as algae, they will not settle out rapidly no matter how large the flocs of cells. Thus a new problem arose: Something had to be added to the solution for extra weight. I tried a clay which is composed of very small negatively charged particles. The hoped-for result was that flocs of clay, algae, and poly would be heavy enough to settle out. I assumed that the clays would not affect the palatability of the algae. I now needed only to find the proper clay.

The following clays were available: Kaolin, Glauconitic, Ferruginous, Argillaceous, Calcareous, Canasauga, Bentonite.

The clay samples were first finely ground and then made into one per cent suspensions by weight. Then the following steps were taken:

1. Nine 20-milliliter spectrophotometer tubes were filled with 900 ppm mixture of Chlorella v., Chlorella p., and Scenedesmus o. species of algae.

2. Three milliliters of each clay solution were added to seven of the tubes, the other two being for controls.

3. One drop of Poly stock solution was added to eight of the tubes, leaving the control without Poly.

4. All tubes were shaken.

5. Final step was to take per cent transmission readings of tubes every five minutes for a 70-minute period.

The settling rates of the seven clays, the Poly alone, and the control were graphed.

With these results we can safely say that Kaolin, Glauconitic, or Ferruginous can be used successfully in the process. However, my feeling is that Glauconitic would be the better choice because Kaolin leaves the algae with an unnatural white color and Ferruginous has a very high iron content which might be harmful. In conclusion, Glauconitic clay shows the greatest promise, at this time, for use in the polyelectrolite separation process.

The following tests were performed to determine at what concentration Poly would operate effectively.

1. Four 20-milliliter spectrophotometer tubes were filled with the mixed culture of Chlorella v., Chlorella p., and Scenedesmus o., at concentrations of 500 (± 50), 1,000 (± 100), 2,000 (± 100), and 3,400 (± 100) ppm.

2. Three milliliters of clay were added to each of the four tubes (Glauconitic).

3. A drop (.04 mi.) of Poly stock solution was added to each tube.

4. All tubes were shaken.

5. Readings of per cent transmission were taken every five minutes for a period of 70 minutes.

The settling rates were recorded.

The graphs show that .08 milliliters (two drops stock) work most effectively in the 150 ml. culture of algae. The order of effectiveness is:

1. 150 ml.
2. 50 ml.
3. 400 ml.
4. 600 ml.
5. 1,000 ml.

Is this new substance, called Poly, harmful to animals? This question must be answered before we can feed algae, separated by the Poly process, to animals.

A mixture of Poly and Purina Laboratory Chow (3,300 ppm) was fed to four white mice for a period of two months (Jan. 11, 1959, to March 11, 1959) while a similar number were fed on the same food for the same period without Poly. This was the control group.

Prepared Purina Laboratory Chow was first ground to a fine powder, then mixed 280 parts to 72 parts of Poly stock solution (10 grams–720 ml. water). More water was added to make a paste. The final step was to hand press the mass into square lumps. The control was prepared in the same way, leaving out the Poly.

No observable differences were noticed in either group (weight, reproduction, and general well being). Because no differences were noticed, I am concluding that Poly has no observable effect upon mice after a period of two months.

CONCLUSION

On the basis of my work so far, I seem to have a practical, safe, and effective way to separate algae from its nutrient solution.

Project and Club News

Science Resource—Your Local Museum

IF YOU haven't visited your local museum lately, you may not realize that museums have become lively centers for helping tomorrow's scientists. Indeed, one of the "prize collections" of many museums is made up of the promising future scientists they have helped.

Dim halls once lined with cases of dusty relics have become colorful rooms featuring dramatic science exhibits. Programs have been developed for students of all ages, and whole science classes come to the museum to learn about flight or space or the mysteries of the oceans.

Science clubs, Scout troops, and other groups hold meetings at many museums to enjoy films, color slides, and the guided tours that are designed to supplement them.

Project-minded students find ingenious display ideas in the professional exhibit techniques used in modern museums. They also discover that the displays and reference collections are a sort of "live" encyclopedia of information for the most varied science projects. Scientists on museum staffs have advised and encouraged many outstanding young scientists.

For example, Frank Wayne Grimm, the Maryland boy who won the $6,000 Westinghouse Science Scholarship in the 18th Science Talent Search conducted by Science Clubs of America, checked his snail specimens with the collection of the Smithsonian Institution in Washington, D. C. Dr. J. P. Morrison, associate curator of mollusks at the U. S. National Museum, encouraged Wayne's research on six unusual land snails he found in the Maryland Piedmont area.

Some museums have student workshops where outstanding students are offered an opportunity to study and work with the science staff. At the Los Angeles County Museum, for instance, students who complete the workshop become members of the Museum Student Association, a junior academy of science, which holds monthly meetings.

The Worcester (Mass.) Natural History Society conducts a nature training school. The Oregon Museum Foundation conducts two-week field expeditions. The Boston Museum of Science conducts a Science Explorer program.

American Museum of Natural History photo

Projecteers can develop ingenious display ideas by studying the techniques used in museums. Displays are also a "live" encyclopedia of information for projects.

If your science club is not already participating in a museum program or using the special facilities offered to tomorrow's scientists, you may find an inquiry most rewarding.

In many sections of the country, all the science clubs in an area join forces for special major activities. The hub of the wheel is the Junior Academy of Science, sponsored and helped by the State Academy of Science or other professional organizations.

Club Help from Academies

Although it is hard to choose a few "for instances" from the multitude of lively programs carried out by Junior Academies, a fair sample might include: Sponsoring and organizing a regional science fair affiliated with the National Science Fair-International; holding regional meetings of Junior Academies which include representatives from all science clubs; cooperating with the senior Academy to hold seminars, career counseling sessions, project "how-to-do-it" meetings, lectures and demonstrations, and laboratory workshops; planning meetings where Academy members present papers on their individual research projects; organizing field trips; and publishing a variety of bulletins and handbooks.

The Knoxville Junior Academy in Tennessee publishes a monthly newsletter and a directory of organizations of special interest to science students. The Academy has established its own Nature Museum, trains its members as museum guides, and offers tours for school classes and other organizations. It also organizes hikes, trips to university laboratories, and a series of lectures.

The Virginia Junior Academy holds Junior Science Days, during which club and individual projects are exhibited by some 200 affiliated science clubs from all over the state.

The Washington (D. C.) Junior Academy sponsors the five regional science fairs within its area and raises funds to help in defraying the expenses of sending the winners to the National Science Fair-International.

Junior Academies everywhere are serving as central contact points for clubs and organizations and as catalysts for a great variety of science project and club activities.

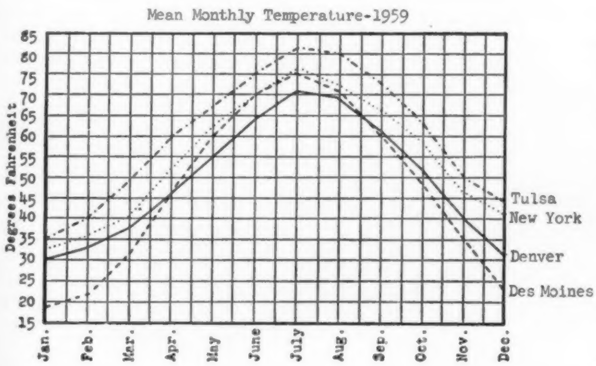
Meeting the Test

The Interpretation of Data in Graphs

By THEODORE BENJAMIN

Data, a group of facts, can appear in a variety of forms. Most commonly they take the form of a table or graph, or they may be included as a series of statements in a report. In many of the important tests and examinations which you encounter nowadays, you may be asked to organize, interpret and draw proper conclusions from given data. To do this, you must draw on the information contained in the statement of the data, and apply the scientific principles you already know to the problem at hand. *Numerical* data calls upon your ability to manipulate numbers in order to get all the information you may need to answer certain questions about them. Try your hand on these test questions that involve interpretation of data.

I. The graph below gives a comparison of monthly mean temperatures for 1959 in four cities in the U. S. For each statement concerning the data given in the graph determine the appropriate letter from the key and write the letter in the space at the left of the statement.



KEY

A. Write **A** in the space at the left if you think the statement is *true according to the facts given.*

B. Write **B** if you think that there is *not enough information given* to decide whether the statement is true or false.

C. Write **C** if you think the statement is *false according to the facts given.*

STATEMENTS

__1. In January the temperature in Des Moines did not go below 15° F.

__2. During 1959 the average temperature for a month at Des Moines was always higher than the average temperature for the same month in New York.

__3. To be more comfortable one should go to Denver in the summer and to Tulsa in the winter.

__4. For any one month in 1959, the difference in average temperature in New York and in Tulsa was never more than 20° F.

__5. For August 1959, the difference between the average temperature in Tulsa and the average temperature in each of the other three cities is in every case less than 20°.

__6. On February 15, 1959, the temperature at Tulsa was 40° F.

__7. In January 1961, the monthly average temperature at Denver will be between 28° and 33° F.

__8. Tulsa is farther south than Denver.

__9. In 1959, the change in the average monthly temperature from winter to summer was greater in New York than in Des Moines.

__10. The mean temperature rise from March to May was most marked in Des Moines.

II. The table below shows the distance in feet traveled *each* second by objects A, B, C, D, and E. Assume that there is no friction. At the left of each statement below write the corresponding letter which designates the moving object to which the item refers.

	A	B	C	D	E
First second	1	16	16	36	15
Second second	3	16	48	24	12
Third second	6	16	80	18	9
Fourth second	10	16	112	24	6
Fifth second	15	16	144	36	3

__11. This object has a uniform velocity.

__12. This object could be falling freely from rest near the earth's surface.

__13. This object comes to rest at the end of the fifth second.

__14. This object has a variable but always positive acceleration.

__15. The acceleration of this object is constant but changes in sign from negative to positive.

__16. The acceleration of this object is 32 feet per second per second.

__17. This object has no acceleration.

__18. This object has a uniformly decreasing velocity.

__19. No force is acting on this object.

__20. The increasing velocity of this object is due to a uniform force.

(Answers are on page 31)

BRAIN TEASERS

A Jar of Amoebas

Suppose there are seven amoebas in the bottom of a jar, and that they multiply so fast that they double in volume every minute. If it takes forty minutes for the amoebas to fill the jar, how long will it take them to fill half the jar?

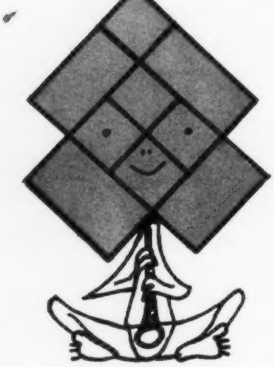
Martha Schenck
311 West Park Drive
Raleigh, North Carolina

Answer: Thirty-nine minutes. The next minute the amoebas would double in volume and fill the jar completely.

Hindu Squares

How many different squares can be found in the diagram below? There may be more than you think.

James Wollensack
Brooklyn, New York



Answer: There are five small squares, five middle-size squares, and one large one, making a total of eleven.

Smart Student

When the famous German mathematician Karl Gauss (1777-1855) was seven years old, his teacher gave him this problem to keep him busy: "What is the sum of all the numbers from 1 to 100?" To the teacher's surprise, little Karl had the answer in a few seconds. What was the answer and how did he figure it so quickly?

Jim Chamberlin
Route 1, Box 306
Sunbury, Ohio

Answer: Young Karl Gauss saw that all the numbers between 1 and 100 could be arranged in pairs, as follows: 1 and 100, 2 and 99, 3 and 98, etc., until 50 and 51. Since the sum of each pair is 101, and there are fifty such pairs, the problem becomes one in simple multiplication: 50 x 101, or 5050. If you want to check this, you can always take the trouble of adding all the numbers from 1 to 100.

Stitch in Time

The Spanish writer Cervantes, author of *Don Quixote,* and William Shakespeare both died on April 23, 1616. Yet they did not die on the same day. Why?

Paul Schneller
33 Wall Avenue
Valhalla, New York

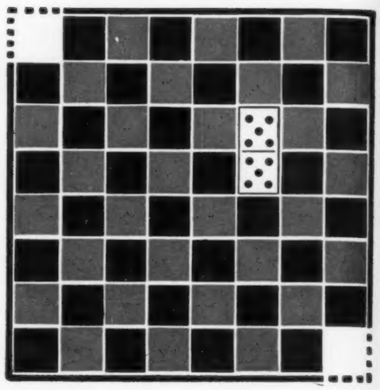
Answer: In the seventeenth century, England and Spain used different calendars. There was a difference of ten days between the Julian Calendar used by England, and the Gregorian calendar adopted by Spain. (The Julian calendar, originating in the time of Julius Caesar, had an error of about 11 minutes a year. This error accumulated over the centuries, and by 1582 amounted to about ten days. At that time Pope Gregory XIII abolished the ancient calendar and substituted a new more accurate calendar which began ten days later. This Gregorian calendar is the one we use today.)

Puzzle in Squares

The props for this puzzle are a chessboard and 32 dominoes. Each domino is of such a size that it exactly covers two adjacent squares on the board. The 32 dominoes can therefore cover all 64 squares on the chessboard.

But suppose we cut off two squares at diagonally opposite corners of the board, leaving 62 squares. At the same time we discard one domino, leaving 31 dominoes. Is it now possible to place the 31 remaining dominoes on the board so that all the remaining 62 squares are covered? If yes, show how it can be done. If not, prove that the problem is impossible.

Clifford Crump
830 Landing Road N.
Rochester 10, N. Y.



Answer: It is impossible to cover the mutilated chessboard (with opposite corner squares cut off) with 31 dominoes, and the proof is easy: The two diagonally opposite corners are of the same color. Therefore their removal leaves the board with two more squares of one color than of the other. Each domino covers two squares of different color, since any two adjacent squares must have different colors.

Therefore, after you have covered 60 squares with 30 dominoes, you are left with two squares still uncovered, which must be of the same color. Since these last two squares are of the same color, they cannot be adjacent, and therefore they cannot be covered by the last domino.

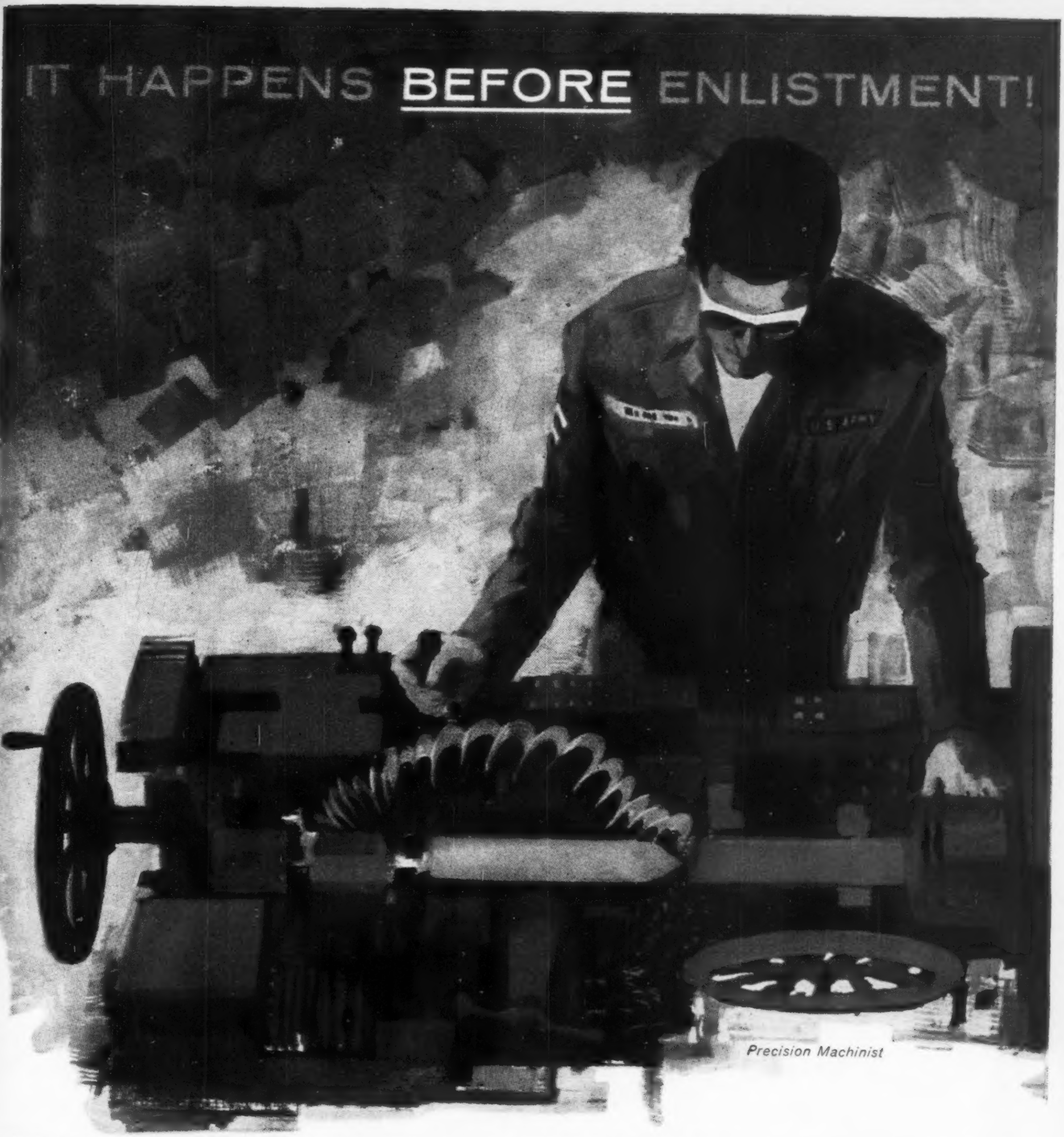
Easy Logic

An Indian town has 20,000 people. 1000 are one-legged and half the others go barefoot. How many sandals are worn in the town?

Answer: All the one-legged people require one shoe apiece. Of the remainder, half will wear two shoes and half none, also making one shoe per person. Therefore, 20,000 shoes will be required.

Send in Your Favorite Brainteaser

You surely have a favorite brainteaser that you would like to share with other readers. Send the brainteaser, together with the solution, to Science W[illegible]ld, *33 West 42nd Street, New York 36 N. Y. We will pay $5 for every brai[illegible]easer published. Include the name o[illegible] your school, in addition to your ho[illegible] address, and state your age.*



Precision Machinist

Nobel Geneticist

(Continued from page 20)

Dr. Beadle, together with some of Dr. Morgan's students, worked on many experiments in genetics. But more and more he believed that many of the unsolved problems in genetics could be studied more effectively by observing precise biochemical changes one at a time in a simple organism, rather than in a complex plant or animal. He reasoned that a trait such as tallness or shortness might be due to many chemical changes. What he needed was an organism in which changes would be due to a single chemical reaction.

Almost Perfect "Guinea Pig"

For several years, Dr. Beadle tried out his theories on fruit flies. He finally concluded they were not the best specimens for chemical genetics. A new laboratory specimen was needed, a much simpler organism that would enable him to observe one reaction at a time. He assumed too that the simpler the organism, the fewer its genes and chromosomes.

In 1937, Dr. Beadle was appointed full professor at Stanford University. It was there, together with Dr. Edward L. Tatum, a chemist, that the red bread mold, Neurospora crassa, was selected as an almost perfect "guinea pig." The advantages in using Neurospora were numerous: it reproduced both sexually and by spore formation, a single spore produced a vast quantity of mold with the same heredity makeup, and a medium of mineral salts, sugar and one vitamin, known as biotin, was all that Neurospora needed to thrive.

The two scientists set to work irradiating the mold with X rays in an attempt to induce mutations. Their goal was to create strains that differed from the normal mold in simple chemical ways. After exposing the spores to X rays they gathered those formed by sexual reproduction and placed them in the nutrient medium required by natural wild molds.

Some grew normally, others died, and a few began but did not continue to grow. Careful microscopic examination sorted out the spores which seemed to be able to grow but for some reason couldn't. This reason the scientists sought. The spores were fed with amino acids, vitamins, and other growth-stimulating chemicals.

After 299 tries, Dr. Beadle and Dr. Tatum found that vitamin B-6 was the missing ingredient needed by the mold to make it grow. When this strain was mated with a normal strain, the need for vitamin B-6 was transmitted to its offspring—according to Mendel's laws.

Two researchers had achieved their goal. The gene which produced the enzyme needed in the mold's process of making vitamin B-6 out of simpler nutrients had been changed by X rays. Without this gene, the mold could not grow without outside help. It was similar to a diabetic's need for an outside source of insulin, which his body is incapable of producing.

The two researchers continued their experiments. Soon they had a great many abnormal molds, each needing an extra nutrient or having some other gene-controlled chemical ailment.

New Genetic Tools

This success with Neurospora provided geneticists with new techniques for using molds and other small organisms as genetic tools. The work of Dr. Beadle and Dr. Tatum determined that genes control enzymes and enzymes control the chemistry of life. In 1958 Dr. Beadle shared the Nobel Prize in Medicine and Physiology with Dr. Tatum and Dr. Joshua Lederberg, another geneticist.

Today Dr. Beadle is director of the California Institute of Technology, Division of Biology. He was appointed to his position in 1946 when Dr. Morgan retired. Dr. Beadle married in 1953 and lives near the Caltech campus in a house that once belonged to Dr. Morgan. There are many flowers in his garden and rows of corn stalks. Perhaps these corn stalks are symbols of Dr. Beadle's boyhood curiosity about the wonders of living things, a curiosity kept alive by an understanding high school science teacher.

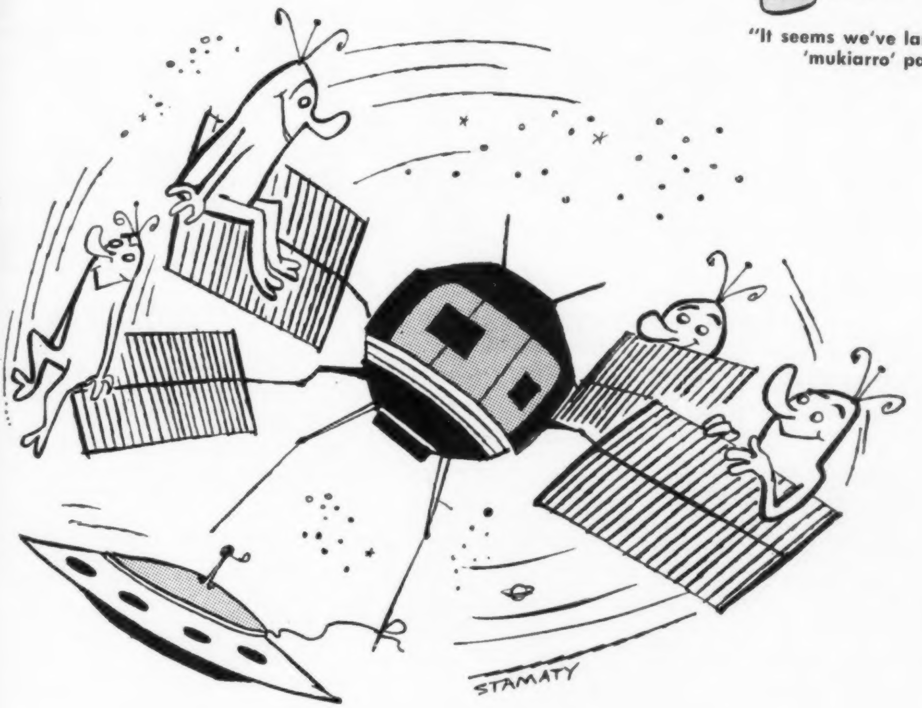
Answers to Crossword Puzzle

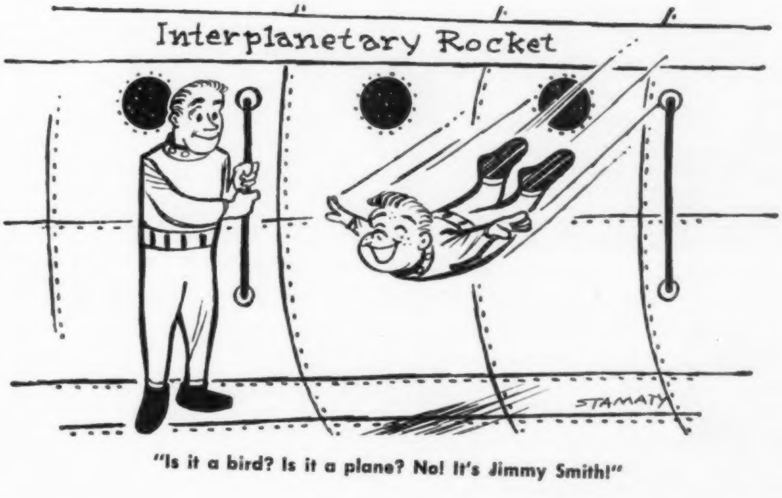
(See page 30)

■	V	I	L	L	I	■	O	R	G	A	N	■
L	■	S	O	S	■	C	■	R	A	M	■	L
I	N	■	G	■	V	E	T	■	R	■	M	Y
V	O	O	■	C	I	L	I	A	■	D	A	M
E	D	■	H	■	A	L	P	■	V	■	U	P
R	■	S	E	E	■	S	■	L	I	D	■	H
■	Y	E	A	S	T	■	S	E	R	U	M	■
O	■	A	R	C	■	N	■	T	U	G	■	M
P	D	■	T	■	M	E	T	■	S	■	M	E
T	O	N	■	S	T	R	I	P	■	S	I	T
I	T	■	F	■	A	V	E	■	M	■	G	E
C	■	L	A	B	■	E	■	B	A	T	■	R
■	W	A	T	E	R	■	A	X	O	N	S	■

Sci-fun

"It seems we've landed in his 'mukiarro' patch."





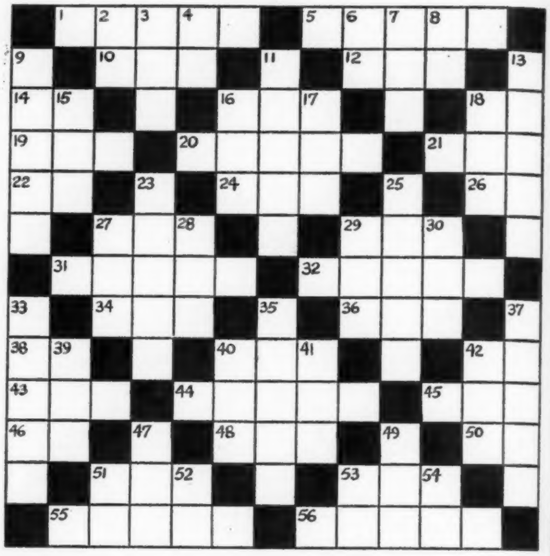
"Is it a bird? Is it a plane? No! It's Jimmy Smith!"

Plant and Animal Life

By Jack Bloom, Junior High School 246, Brooklyn, New York

★ Starred words refer to biology

Students are invited to submit original crossword puzzles for publication in *Science World*. Each puzzle should be built around one topic in science, such as astronomy, botany, geology, space, electronics, famous scientists, etc. Maximum about 50 words, of which at least 10 must be related to the theme. For each puzzle published we will pay $10. Entries must include symmetrical puzzle design, definitions, answers on separate sheets, design with answers filled in, and statement by student that the puzzle is original and his own work. Keep a copy as puzzles cannot be returned. Give name, address, school, and grade. Address Puzzle Editor, Science World, 33 West 42nd Street, New York 36, New York. Answers to this puzzle are on page 28.



ACROSS

* 1. Minute, thread-like processes in the small intestine.
* 5. Part of animal or plant that performs a specific function.
10. Signal call of distress.
*12. A male sheep.
14. Indium (*chemical symbol*).
*16. He treats sick or hurt animals.
18. Showing singular possession.
19. Haitian sorcerer, ______ doo.
*20. Hair-like structures in paramecia.
21. Structure to hold back water.
22. Editor (*abbr.*).
24. A very high mountain.
26. Direction of movement contrary to that of gravity.
27. Look.
*29. The operculum in mosses.
*31. Fungus causing fermentation.
*32. Portion of the blood containing antibodies.
34. Part of a circle.
36. Pull hard.
38. Police Department (*abbr.*).
40. Past tense of meet.
42. Methyl (*chemical abbr.*).
43. Two thousand pounds.
44. Pull off.
45. Rest with weight on lower part of trunk of body.
46. Rome is its capital (*abbr.*).
48. Avenue (*abbr.*).
50. Chemical element of atomic No. 32 (*symbol*).
*51. Room for biology experiments (*abbr.*).
*53. Flying mammal.
*55. Medium by which materials in plants are transplanted.
*56. Neurons contain ______ and dentrites.

DOWN

2. Third person singular of verb to be.
* 3. A length of tree trunk.
4. Left side (*abbr.*).
6. Railroad (*abbr.*).
* 7. Long, slender fish.
8. After midnight and before noon.
* 9. Organ of body in which glycogen is stored.
*11. Human body is made of trillions of ______.
*13. Fluid which bathes the cells.
15. Shake of head.
16. By way of.
*17. The rootcap is located at the ______ of a root.
18. Name of African tribe, ______ Mau.
*23. Pumping station of blood to body.
*25. Infective agent of disease.
27. Large body of water.
28. Economic and Social Council (*abbr.*).
29. Allow.
30. Excavated.
*33. Relating to sense of sight.
*35. Tissue specialized for rapid impulses.
37. Unit of length in metric system.
39. Very small spot.
40. Metropolitan Transit Authority (*abbr.*).
41. Draw together, fasten.
42. Russian jet fighter plane.
*47. Chemical substance composed of carbon, hydrogen, and oxygen.
49. Secretary of the Chinese Communist party, ______ Tse-tung.
51. Sixth note of diatonic scale.
52. Exist.
53. Box (*abbr.*).
54. Thoron (*chemical abbr.*).

Bookshelf

PEOPLE AND PLACES, by Margaret Mead (The World Publishing Co., 1959, 318 pp., $4.95.)

"Wherever we find human beings, we find that they wonder about other people . . ." Dr. Mead begins. Thus the world-famous anthropologist starts on that fascinating subject—man.

In the first section she surveys what anthropologists have learned by studying primitive peoples living today.

In the second section Dr. Mead discusses five significant cultural groups—the Eskimos, the Indians of the Plains, the Balinese, the Minoans of Crete, and the Ashanti. She shows how each group—having the same basic human needs—developed differently depending on its environment, contacts, and dominant interests.

In the final section Dr. Mead gives a thought-provoking summary of the basic ideas that all men share, and the questions that are answered in different ways by different people.

STARS IN THE MAKING by Cecilia Payne-Gaposchkin (Harvard University Press, 1953, 160 pp. $4.25 (hardcover); Pocket Books, Cardinal Giant, 1959, 50¢.)

Here is the drama of the birth and life and death of the stars. It is a drama with a datable beginning and a determinable future life span. The characters are dazzling: bright red supergiants, dim white dwarfs, bursting supernovae, pulsating variable stars, great masses of interstellar dust and the basic component of the universe—atoms.

Here are stars in action. Out of their spinning, shedding, spilling and exploding, Dr. Payne-Gaposchkin knits a connected story. She tells how they emerge, how they are nourished, how they expend their radiant energy and how they eventually degenerate.

WOMEN OF MODERN SCIENCE, by Edna Yost (Dodd, Mead, 1959, 176 pp., $3.00.)

The twentieth century has witnessed an increasing number of women assuming vital roles in modern science. In her latest book Edna Yost, who is also author of *American Women of Science* (Lippincott, revised edition, 1955), has presented eleven portraits of gifted women who have made outstanding contributions to research.

Gerty Cori, with her husband, won a Nobel Prize in Physiology and Medicine—the only American woman who has achieved this honor.

Florence Van Straten, who joined the Waves in World War II, was assigned to meteorological work and has helped develop the Naval Weather Service.

Chien Shiung Wu, born near Shanghai, China, is professor of physics at Columbia University. As a nuclear physicist her work has helped to change previously held concepts concerning the physical structure of matter and the universe.

Not until she was a college student did Helen Sawyer Hogg have any idea that she would ever want to be an astronomer. Under the stimulation of a devoted teacher, the attraction of the stars became strong enough to set the course for her future. She is now on the staff of Toronto University.

Edith Hinkley Quinby helped create the new science of radiation physics.

—LAVINIA DOBLER

Answers to Meeting the Test

(See page 25)

1-B; 2-C; 3-B; 4-A; 5-A; 6-B; 7-B; 8-B; 9-C; 10-A; 11-B; 12-C; 13-E; 14-A; 15-D; 16-C; 17-B; 18-E; 19-B; 20-C.

On the Job Research

Perhaps you or some of your bright young students have wondered how rare antibodies are detected in cattle serum; or how the action of herbicides on cotton and oats is related to the different levels of nitrogen, potassium, phosphorus, and other minerals available to the plants?

If these questions have not crossed your mind, don't worry about it; these and other related problems will be subjected to research this year by two high school science teachers assisted by some of their prospective future scientists.

The two research projects described are being supported by financial grants provided by the Future Scientists of America Foundation (FSAF) to encourage research participation by high school science teachers. The recipients are Mr. Charles W. Anderson, who teaches in the high school at Norwood, Minnesota, and Mr. Hollis C. Fenn, a science teacher in the high school at Petersburg, Virginia. Mr. Anderson did preliminary work on his cattle serum project at the University of Wisconsin last summer and will continue, as in the past, to have Dr. W. H. Stone of that institution as his science consultant.

Assisting Mr. Fenn in his research on herbicides will be Dr. Donald Moreland of the Agricultural Research Service, U. S. Department of Agriculture, Raleigh, North Carolina. Mr. Fenn also began his study last summer as part of a research participation program at North Carolina State College.

The provision of grants to encourage on-the-job research participation by high school science teachers is one of the major activities of FSAF this year. Funds are available to make a small number of grants ranging from about $250 upward.

Teachers are encouraged to take advantage of this opportunity and to assist FSAF in a continuing pilot run of the validity of this idea. Further information on how to apply for a research grant to explore some problem you are interested in may be obtained by writing directly to NSTA headquarters, 1201 Sixteenth Street, N.W., Washington 6, D.C.

Junior Academy of Science

If your science club or class is not familiar with the activities of the Junior Academy of Science in your area, you might suggest the formation of a committee to investigate the details and report on ways in which your club may participate.

Serving on the various councils and governing boards of the Junior Academy offers an opportunity for nearly-adult activity that may be an invaluable experience for a promising student. He also may meet and work with eminent members of the senior Academy, in this way learning to know and appreciate professional scientists as human beings and as researchers and experimenters who are enthusiastic about the work they do.

Museum as a Resource

Encourage your science classes and/or science club to take full advantage of the excellent facilities made available by modern museums to groups and to individual students who are genuinely interested.

You may want to explore the possibilities of taking entire classes to the museum for films and tours on specific subjects. This can be such a rewarding experience that it is worth considering even if it involves a trip of some distance. Museum staffs usually are very glad to cooperate in planning exceptionally interesting programs to supplement classroom work or club projects.

Eighth Annual NSTA Convention

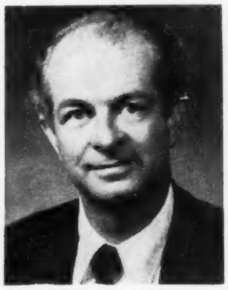
Dr. Donald G. Decker
NSTA President

Robert H. Carleton
NSTA Executive Secretary

Dr. John Fischer
Dean, T.C., Columbia U.

Dr. George Kistiakowsky
Science Advisor, President

Dr. John R. Heller
U.S. Natl. Cancer Inst.



Dr. Linus C. Pauling
Calif. Inst. of Technology

STEPPED up school science programs—from kindergarten through the 12th grade—will be the main concern of approximately 2,000 teachers when they meet in Kansas City, March 29-April 2, for the eighth annual convention of the National Science Teachers Association (NSTA).

Some of the nation's top practicing scientists will be working closely with convention participants to study the role and importance of a broad and continuous science program for all students as sessions get under way in Kansas City's Municipal Auditorium.

Predictions for an outstanding convention were forecast by Robert H. Carleton, NSTA executive secretary, as he announced program plans and reported that two Nobel Prize winners head the roster of distinguished speakers. They are Dr. Linus C. Pauling and Dr. Walter H. Brattain.

"Frontiers of Science" Program

Dr. Pauling, who won the 1954 Nobel Prize in Chemistry, began teaching at the California Institute of Technology in Pasadena in 1922. He received his doctorate there in 1925, and is currently professor of chemistry. He has received 14 world-known awards for his contributions and discoveries in chemistry, medicine, and international law; he has been given honorary doctorates by 17 universities.

Dr. Brattain is a co-winner of the 1956 Nobel Prize in Physics for his investigations in semiconductors and the discovery of the transistor effect. Since 1929 he has been with the Physical Research Department of the Bell Telephone Laboratories in Murray Hill, New Jersey. He was born in China, educated in Washington and Oregon, and received his Ph.D. from the University of Minnesota.

NSTA President Donald G. Decker, who is dean of Colorado State College at Greeley, will set the stage for discussions throughout the convention at the opening general session as he outlines the problems and issues involved in teaching science today.

Science topics will be explored in an extensive "Frontiers of Science" series of discussion sessions. Addresses by college and research scientists will pinpoint recent developments in the major fields of science—biological science, physical science, earth science, and health.

Included also on the "Frontiers" program series, in addition to Dr. Pauling and Dr. Brattain, will be such outstanding speakers as Dr. George B. Kistiakowsky, science advisor to President Eisenhower, and Dr. John R. Heller, director of the U.S. National Cancer Institute, Bethesda, Md.

Dr. Kistiakowsky was born in Russia and was educated in Moscow and Kiev. He received his Ph.D. from the University of Berlin in Germany. He has been a member of the teaching staff at Princeton University and holds the chair of professor of chemistry at Harvard University. He has been associated with national defense efforts since 1944 and was appointed to President Eisenhower's Science Advisory Committee in 1957.

Winners in STAR '60 Program

Dr. Heller began his career with state and national public health offices in 1930 and has served as Chief of the U.S. Division of Venereal Diseases and Assistant Surgeon General, U.S. Public Health Service. His work includes the fields of medical research administration, public health administration, epidemiology, international cancer control, venereal disease control, and medical education.

Other convention speakers include Dr. Robert H. Johnson, superintendent of Jefferson County public schools, Lakewood, Colo.; Dr. Leona M. Sundquist, chairman, Department of Science, Western Washington College, Bellingham; Dr. Joe Zafforoni, professor of science education, University of Nebraska, Lincoln; and Dr. John H. Fischer, dean, Teachers College, Columbia University, New York City.

For the first time, conferences for science supervisors, consultants, and coordinators will be conducted under NSTA sectional status on the mornings of March 29 and 30, at the start of the convention. The Thursday evening general session on March 31 will feature the announcement of winners in the STAR '60 awards program for science teachers. Winners are selected on the basis of entries demonstrating effective science teaching methods. The first award of $1000 and 55 others totaling $12,500 will be presented.

Science Teaching Materials

Approximately 100 commercial exhibits, the largest number displayed at any NSTA convention, will be presented in the Exposition of Science Teaching Materials in the Kansas City Municipal Auditorium, where all general convention sessions will be held. Banquet and luncheon sessions and other related meetings are scheduled in the two convention headquarters hotels, the Muehlebach and the Phillips.